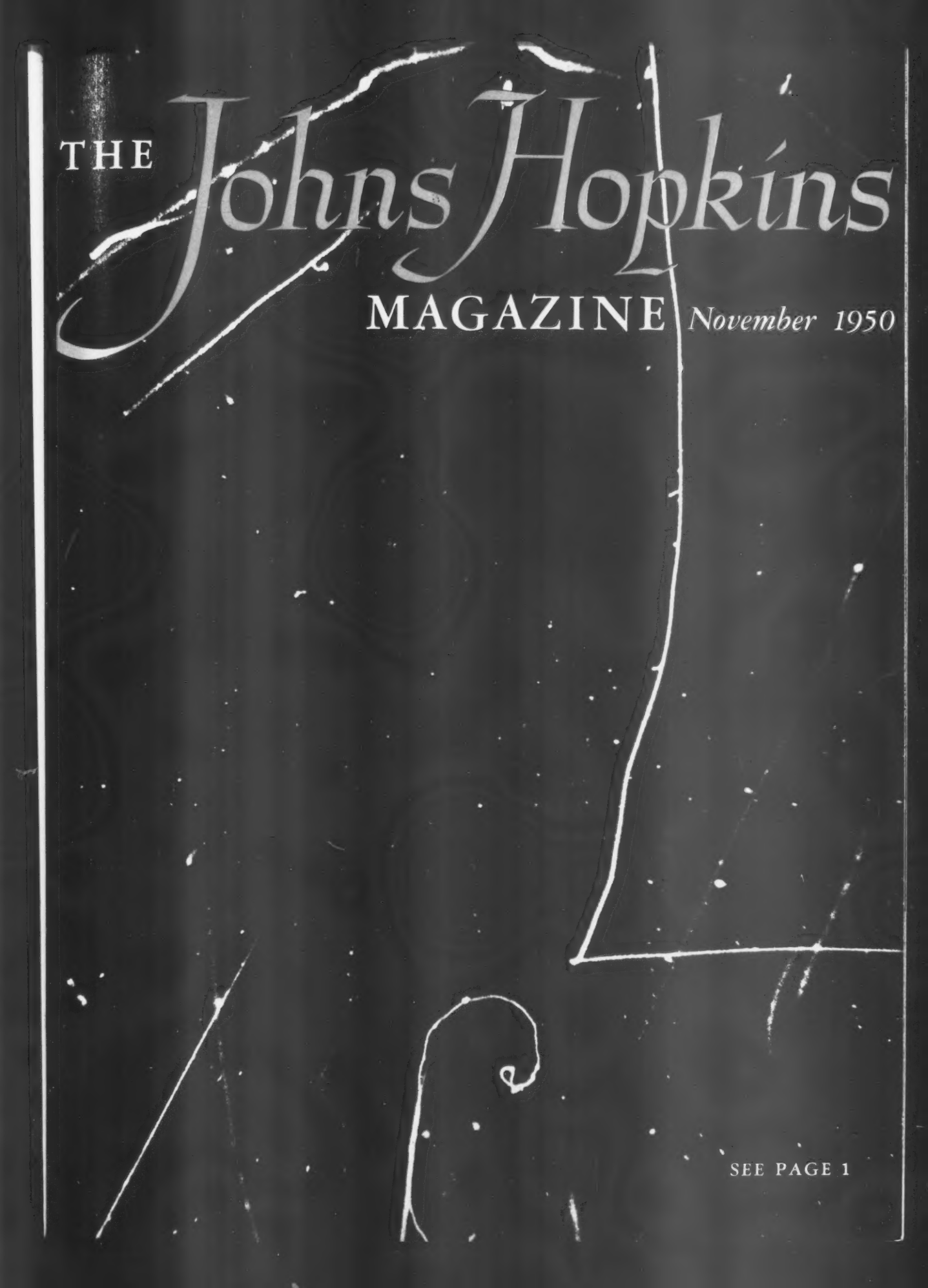
THE Johns Hopkins MAGAZINE

November 1950



SEE PAGE 1

Wonderful way to feel!

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Wonderful way to feel, isn't it?

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U. S. Savings Bonds will bring you, in ten years, $4 for every $3. And you can count on that!

Start your plan today. It's the very wisest way to save!

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THE Johns Hopkins MAGAZINE

VOLUME II November, 1950 NUMBER 2

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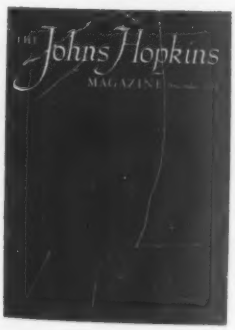

The Cover

The cover shows a nuclear "event" in the cloud chamber at Brookhaven National Laboratory. The long vertical line is a mu meson. It disintegrated where the line ends, producing an electron (the right-angle path) and a neutrino, which, lacking an electric charge, is invisible.

Photo by Brookhaven National Laboratory

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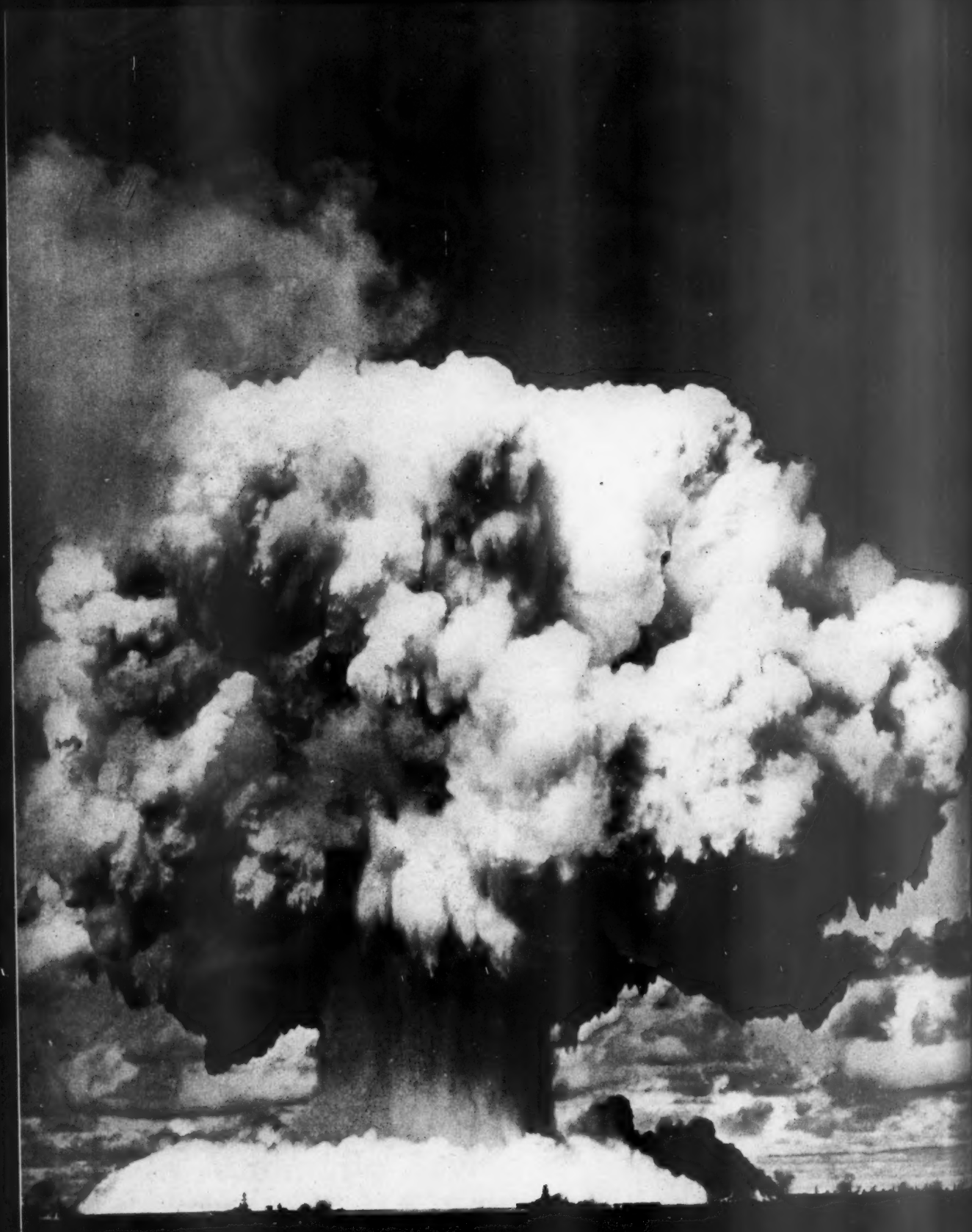


First impressions

count. The atom bullied its way into people's consciousness in 1945 as a destructive force, the most awful that man had ever seen. And people have seldom thought of it as anything but a bully ever since. ¶For a few optimistic months after the war's end—those months when people of the world permitted themselves to think of their futures in terms of uncomplicated hope and peace—there was talk of the atom's Potential for Peace: hopeful talk that spoke of harnessing the awful atom to people's peaceful needs. ¶But the first idea did not die. The years that followed have been years of mounting fear among men that their dreams of peace must fade. They have been bitter years for some, dissolving cherished faiths. They have been years which to many have left a legacy of hopelessness and cynicism, years which to many have said, "Why plan? Why build? Why breed? For whatever you create must crumble, before a force no man controls." ¶That is the role of the atom: the Thing that is all bad. For some. ¶But there are others who have different views. They *are* building. They *are* planning. Not simply because it is a convenient way to pass the time till doom. They think the world *has* a future, not all dark after a blinding, killing flash of bomb. ¶It is worth looking at what they are doing. They are building buildings and world organizations, even as the planet quakes. They are sowing seeds for next year's crops, and building dams to irrigate next century's. ¶And, these men of hope, they are even working for the human race with the *atom*, of all things.

The articles which follow in this issue of The Johns Hopkins Magazine discuss some of the things men are doing, at Hopkins and elsewhere, to make "the atom" work for man.

BROOKHAVEN

Nine universities operate this great new atomic laboratory—where scientists are conducting nuclear research for peace.

By R. W. DODSON

NEAR the center of Long Island, sixty-five miles due east of New York City, a huge scientific establishment has come into being during the past three and a half years—the Brookhaven National Laboratory. This collection of buildings, people, and apparatus is the country's greatest present investment in long-range, non-military, essentially peaceful research in atomic energy.

It is a venture sponsored by a group of universities, supported with public funds by the Atomic Energy Commission, centered about advanced and elaborate instruments of investigation in nuclear science. As laboratories go it is an infant; its future is more important than its present or brief past. If the future holds the realization of the aims of its founders it will be a great center of research directed toward a better understanding of the atomic nucleus and of diverse problems in many other sciences.

The Laboratory is operated under contract with the Atomic Energy Commission by a group of nine eastern schools—Yale, Columbia, Princeton, Harvard, Johns Hopkins, Cornell, Rochester, Pennsylvania, and the Massachusetts Institute of Technology—who have formed a corporation, Associated Universities, Inc., for this purpose.

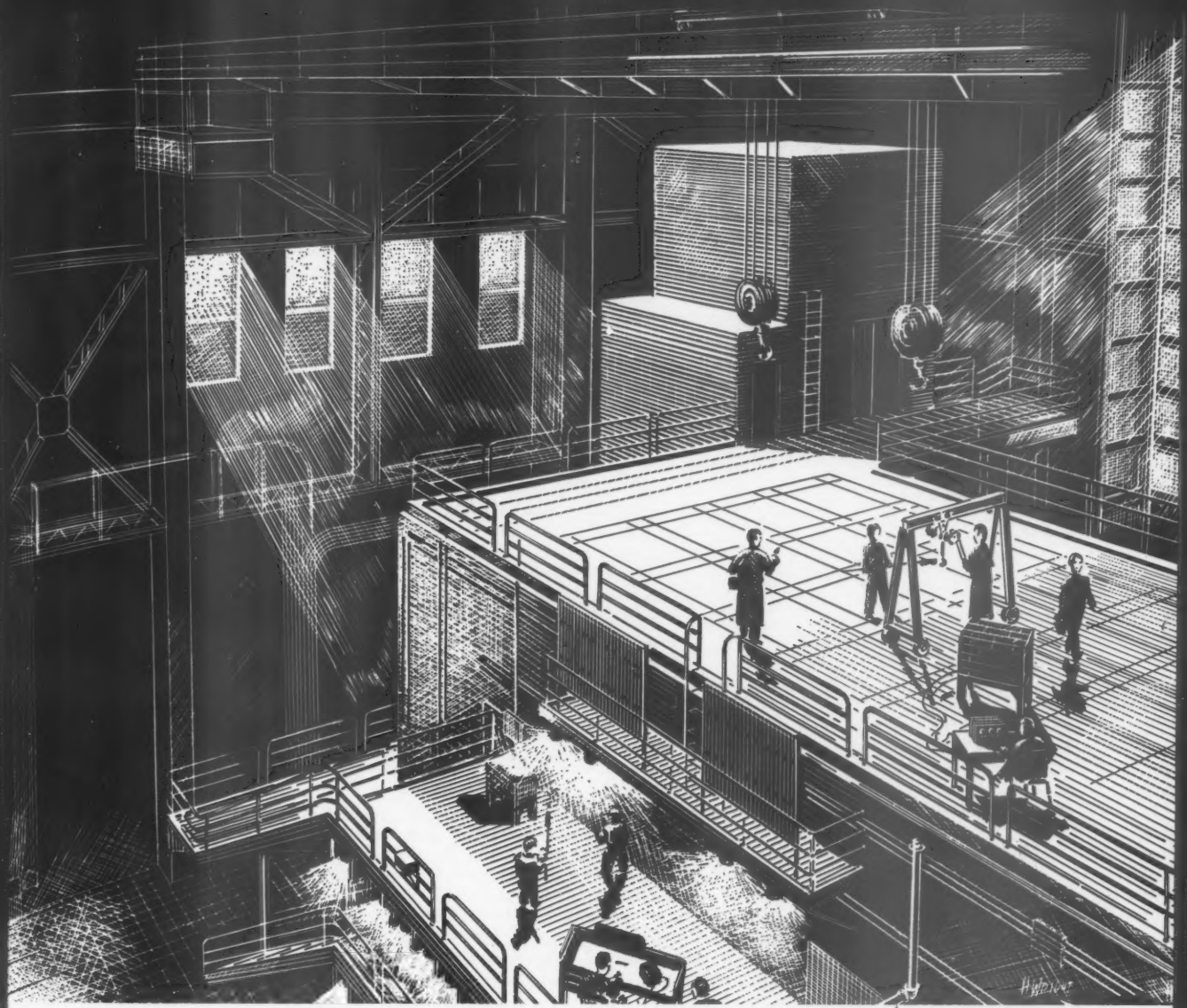
By the terms of its contract, Brookhaven is to engage in and foster fundamental research in atomic energy and related fields. The investigations are to be carried out both by its own staff and by visiting scientists. In its relationships with a government agency, a group of universities, and the scientific community at large, the Laboratory is in itself a new experiment in collaboration.

DISINTEGRATION OF PARTICLES in the nucleus of an atom is studied in the cloud chamber at Brookhaven. Invisible themselves, nuclear particles leave trails in atmosphere supersaturated with alcohol or water vapor, which can be photographed (see cover).

BROOKHAVEN stands just on the eve of the attainment of its first major objective: to provide certain large and powerful machines for causing nuclear phenomena. These devices, which both physically and in the imagination loom large in one's present view of Brookhaven, are a nuclear reactor and a super-high-energy particle accelerator, or cosmotron.

The first, by controlled-fission chain reaction, is distinguished by an aspect of quantity. In it occur nuclear reactions on a large scale: large amounts of radioactive isotopes and of neutrons (the particles which propagate the chain reaction) are generated. Its usefulness as a research tool is that, in contrast say to

DR. DODSON, who received his Ph.D. in chemistry from Johns Hopkins in 1939, is chairman of the Chemistry Department at Brookhaven National Laboratory.



BROOKHAVEN'S NUCLEAR REACTOR is the most versatile anywhere. It is specifically designed for efficient research experimentation. Reactor produces neutrons and radioactive isotopes by controlled-fission chain reaction. Like the one at Oak Ridge, it consists of a chain-reacting assembly of uranium metal slugs, placed in a lattice of graphite blocks. It "went critical" late in August.

the means at hand in 1933, it makes these products in amounts some million billionfold greater.

The second machine is distinguished by a qualitative aspect, that of moving particles to such speeds that their energy is some millionfold greater than the energies of particles available for nuclear bombardment in 1933.

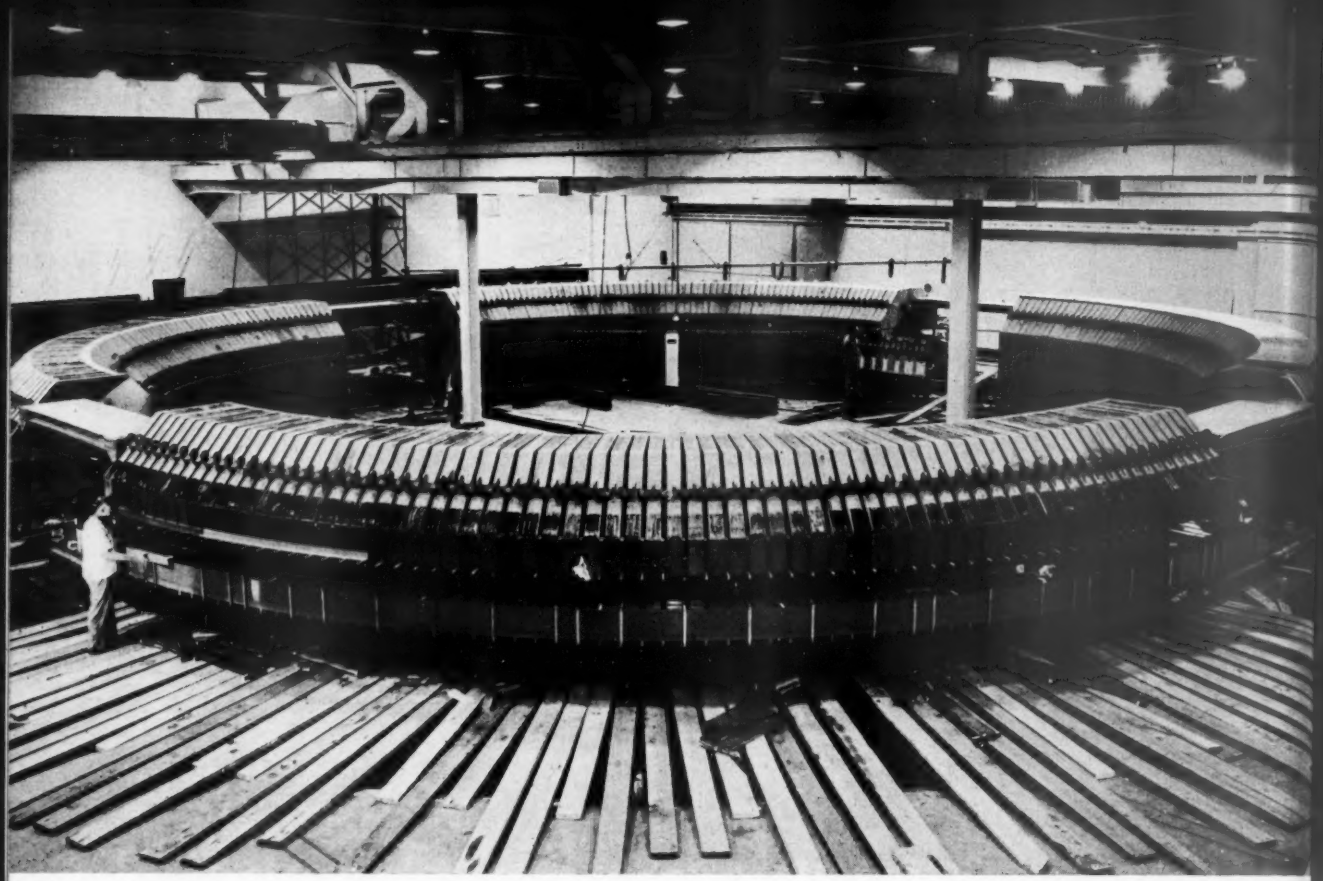
The amplification of quantity allows the experimenter to work with substances and phenomena formerly too rare for observation and adequate study. The extension of energy range will enable him to cause and study events of a brand new character, never before caused by man (although occurring as rare events in the cosmic radiation). These two research tools complement each other, each extending in a different way the resources of experiment.

Because of the striking character of such machines, it is well to remark on the obvious but sometimes forgotten fact that they accomplish no fundamental research by themselves. They merely implement the thoughts of the scientist, whose highly personal function it is to phrase intelligent questions to ask of nature, to plan experiments, carry them out, draw conclusions from the results—and in the light of these phrase new questions.

Photographs from
Brookhaven National Laboratory

Nevertheless, it must also be remembered that a new tool may not only enable long-standing questions to be probed with increased effectiveness, but may also suggest paths into unexplored areas and thus stimulate the investigator to pursue new and fruitful lines of thought. It has been attempted to establish an atmosphere at Brookhaven in which this will be possible. Research problems are selected in the light of their scientific interest. Unclassified rather than secret research is encouraged. The Laboratory welcomes visiting scientists who are qualified to make use of its facilities.

The scientific staff of the Laboratory is organized along lines very much like those of a university faculty. Thus,



rookhaven's Cosmotron It is a device for accelerating protons, the positively charged nuclei of hydrogen atoms, to an energy between two and three billion electron volts. It is called a cosmotron because it will produce energies as high as some of the primary cosmic rays which come from space beyond the earth's atmosphere. Knowledge of atomic structure will be increased thereby.

288 MAGNETS like this one make up the gigantic cosmotron. The magnets will hold moving protons on a circular path until, racing faster and faster, they reach energy desired. To attain this energy, they must circle the path three million times.

there are Departments of Physics, Chemistry, Biology, and Medicine. A Department of Instrumentation and Health Physics is concerned with electronic equipment for research and with safeguards against radiation.

The Department of Reactor Science and Engineering and the Accelerator Department are organized around the two large research facilities which have been mentioned. Their first tasks have been to design the reactor and cosmotron, respectively, and to see through their construction.

ON August 22, 1950, the efforts of the Department of Reactor Science and Engineering came to fruition when the nuclear reactor "went critical" for the first time. The operating characteristics are being carefully determined as the power level is gradually increased. When these important but transient studies are completed, the reactor's floods of neutrons will be available to chemists, physicists, biologists, physicians, and engineers, from Brookhaven and elsewhere, for experiments in their various fields.

In basic design the reactor follows established principles. Like the Oak Ridge pile it is a chain-reacting assembly of uranium metal slugs placed in a lattice of graphite blocks. The enormous power which it generates must be dissipated by a cooling system. For this purpose 300,000 cubic feet of air a minute will be drawn through channels in the structure and exhausted through a stack. This red-and-white-banded tower is one of the tallest structures on Long Island.

The reactor is operated in connection with thorough meteorological-service and radiation-survey stations so that the stack effluent, which contains short-lived radioactive argon, is dissipated harmlessly in the atmosphere, and offers no radioactive hazard to the surrounding communities.

Although the basic design of the reactor is, so to speak, "standard," many of its features are unusual. It has been designed specifically for research purposes. The highest feasible neutron flux has been provided. A multitude of holes in the concrete shield and lattice struc-

ture make it possible to set up individual experiments to use beams of neutrons or to irradiate samples. It is possible to move a sample by pneumatic tube into and out of the pile in a matter of seconds for study of short-lived effects caused by neutron bombardment.

The refinements which increase the reactor's usefulness as a research tool are features which also increase the complications of design and construction. Because of these, the unit took longer to construct and was more expensive than if it had been a carbon copy of the Oak Ridge reactor, which it resembles. Also because of these refinements it is undoubtedly the most versatile research reactor in existence.

BROOKHAVEN'S other large machine is the proton synchrotron, or cosmotron, a device for accelerating protons, the positively charged nuclei of hydrogen atoms, to an energy between two and three billion electron volts. Although it resembles an overgrown cyclotron in that it accelerates ions (electrically charged particles) in a roughly circular path by many repeated pushes given at a particular point on the path, the cosmotron differs in important respects from a cyclotron. In the latter a magnetic field is maintained essentially constant over a cylindrical volume in which the ions move, spiralling out from the center as they are accelerated by a potential applied with constant frequency across a gap.

In the cosmotron, particles move in an orbit of constant radius. Once on each round they are accelerated across a gap by a potential applied from an oscillator whose frequency is varied in just such a way that the circling ions keep in phase with it.

As they move, the ions are held in their sixty-foot orbit by a magnetic field which is increased continually in just the right way to hold the orbit radius constant and prevent the particle from spiraling out. Thus the magnetic field is required only in a ring of sixty-foot diameter rather than throughout the volume of a sixty-foot diameter cylinder.

The protons will circle in this field inside an evacuated doughnut, going faster and faster in each revolution with a consequent increase in their kinetic energy. They will make three million revolutions and travel as far as from the earth to the moon before they reach their final energy.

The purpose of building such an accelerator is to study the events which occur when a particle moving with billion-volt energy interacts with the component particles, or nucleons, of atomic nuclei. From experiments with existing accelerators at about one-tenth the energy, and from observations on cosmic rays, one knows qualitatively some of the events to expect.

Atomic nuclei will be shattered into fragments ranging in size from large chunks of the original nucleus to a multitude of their component nucleons (neutrons and protons). Mesons, the particles intermediate in mass between electrons and nucleons, will be created by the conversion of energy into matter. The cosmotron should constitute a powerful source of these particles, which are believed to be responsible for the forces which bind nucleons together in a nucleus. There are different kinds of mesons; the roll call is probably not yet complete. The cosmotron may lead to the discovery of new varieties of this mysterious entity.

It may also permit observation for the first time of the creation of nucleons themselves, which, being heavier than mesons, require more energy for their materialization.

THERE are several other particle accelerators at Brookhaven, each implementing in its own way the broad research program of the Laboratory. To be attached to the cosmotron itself is a Van de Graaff generator. This unit, which creates an electric field by transporting an electric charge on a moving belt from one end of the machine to another, will be used to give protons their initial boost into the circular orbit of the cosmotron.

A second Van de Graaff is being used by members of the Physics Department in studying the reactions of protons at several million electron volts. A sixty-inch cyclotron will be used in a wide variety of experiments with beams of protons, deuterons, helium nuclei, and neutrons, and also will supply radioactive isotopes which cannot be made in the reactor.

Chemists are operating a two-million-electron-volt Van de Graaff generator as an accelerator for electrons, using the electrons and the X-rays made by the electron beam to cause chemical changes in matter.

THE earth is constantly being bombarded from all directions in space with

RADIOACTIVE IRON, obtained from chemically treated blood or tissue samples, is electroplated with this apparatus in Brookhaven's Biology Department, then precisely measured for radioactivity.

HEAVY WATER is exposed by this Brookhaven physicist to gamma rays from a strong radioactive source. Exposure will produce neutrons. Measurements will aid in studying gamma ray properties.

OBSERVING and manipulating radioactive bacteria colonies are done with this Brookhaven device. Colonies are viewed with stereoscopic microscope. Apparatus protects observer from radiation, keeps colony sterile.

high-energy radiation, known as cosmic rays. The primary rays, believed to be protons, disrupt nuclei when they strike the earth, generating secondary radiation. Study of these radiations has in the past been very fruitful, leading for example to the discovery of the positive electron and of the several known varieties of mesons.

Brookhaven physicists are among the many groups engaged in the study of cosmic rays. Interest at the Laboratory centers upon the mechanism of meson formation and on the properties of the mesons themselves, questions which can be more thoroughly studied with the cosmotron when it comes into operation.

Experiments are being carried out at sea level, on a mountain in Colorado, in high-altitude B-29 flights, and with balloon flights to the top of the atmosphere. Photographic plates, cloud chambers, and Geiger counters are used to observe the radiations and their reactions with nuclei.

One kind of question which has been studied is how the number of mesons formed in the encounter of a cosmic ray proton with a nucleus varies with the proton energy and with the complexity of the struck nucleus. It has been concluded that in a single proton-nucleon collision usually only a single meson is produced. Protons can produce several mesons from the same nucleus, but they do this by colliding successively with several of the nucleons, not by making several mesons in a collision with a single nucleon.

THE reactor will support a variety of investigations in neutron physics. Neutrons are both scattered and absorbed by nuclei. Absorption is followed by any of a large number of transformations of the resulting composite nucleus (gamma-ray emission, emission of particles, fission). The yields of the various reactions vary widely from nucleus to nucleus, and in each case depend on the energy of the neutron. They furnish significant information about the structure and energy states of nuclei, and are important in considering materials to be used in fission chain-reacting devices. For these reasons, the measurement of neutron reaction yields is an important part of the program in physics.

Various means are used to obtain neutrons of known energy. One means is to sort out neutrons of a given energy by reflecting them from a crystal. Like all particles, neutrons exhibit wave-like properties: the wave length depends on the energy. Neutrons of different wave lengths are reflected at different angles by a crystal, so by selecting a given angle one establishes the energy of the neutrons with which he is working.

MOUSE housed in glass metabolism cage is fed sucrose containing a minute quantity of radioactive carbon. This Brookhaven research is designed to trace course of sugar carbon atoms through the body. Amount present in organs, tissues, excreta, and expired air is measured over a period of time after feeding.

Another method is to fix the neutron velocity by observing only those neutrons which travel a given distance in a given time. This is accomplished either by a combination of mechanical shutters, or by generating the neutrons in bursts and causing the detector to be sensitive for brief intervals with a known time delay after each burst. The latter method will be used with the sixty-inch cyclotron and is useful in a higher energy range than the crystal or mechanical-shutter methods. For still higher energies the neutrons made by protons from the Van de Graaff accelerator will be used.

Because of their wave-like properties, neutrons, like X-rays, are scattered by crystals in a way which depends on the arrangement of the atoms in the crystal. They supplement X-rays as tools for structure determinations. Chemists and physicists at Brookhaven will investigate the structure of solids by this approach.

Neutron beams also behave like light in sometimes experiencing total reflection at an interface between different substances. The neutron mirror technique has many potentialities for studying the interactions between neutrons and matter, and is receiving attention in the physics program.

Like atoms, nuclei exist in different energy states. The one of lowest energy is called the ground state; the ones of higher energy, excited states. The energy states of atoms are revealed by the frequencies of the light which they emit. Correspondingly, the energy states of nuclei are found by measuring the energy of the "light" (in this case gamma radiation) which they emit, or the energy of the particles ejected in transitions from an excited state to a lower state. The measurements are carried out by many different experimental techniques; they have the common objective of determining the energy and other characteristic properties of the excited levels.

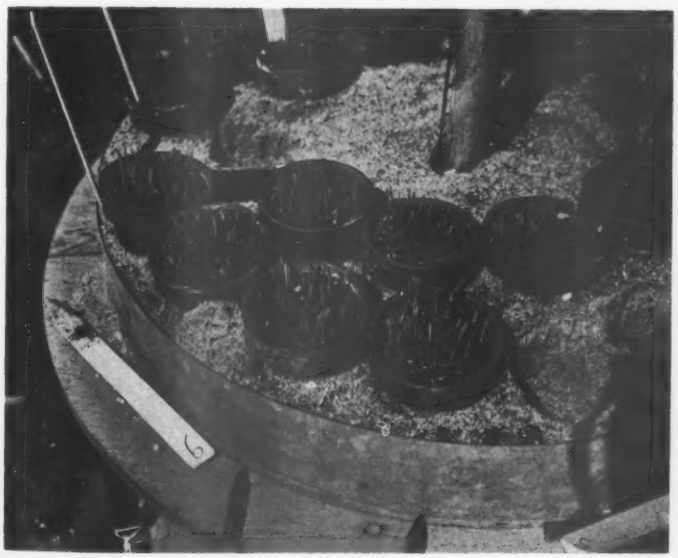
GAMMA rays are usually emitted very quickly, in less than a millionth-millionth of a second. Sometimes, however, excited levels have a life which is long enough to be measurable, from a millionth of a second to many days. These long-lived states are called isomeric states. The careful study of nuclear isomers offers the possibility of determining not only the energy of the excited level, but also its angular momentum and other less accessible but important properties. For this reason a survey of the isotopes is being made to discover new isomeric states, and determine their characteristics.

An interesting case is that of the lead nucleus Pb^{204}. This nucleus can be formed in an excited state which decays with a lifetime of about an hour to a lower excited state which in turn decays with a life of about a third of a millionth of a second. It is found that the direction in which the second gamma ray is emitted depends on the direction of the preceding ray. This shows a striking fact that a nucleus can "remember" its orientation in space for at least a large fraction of a microsecond—a very long time indeed on the nuclear scale.

The properties of nuclei in their ground states are basic facts of nature, and even at present are for the most

Continued on Page 29

WHAT EFFECTS does constant exposure to radiation have on plant life? Brookhaven biologists have planted a variety of crops in widening circles around a source of radioactive cobalt, located in a pipe at the center of the hexagonal field above. Scientists are studying the effects on plants' growth, the production of mutations, and changes within individual plant cells. The cobalt source equals approximately twenty grams of radium, and bathes the closest plants in a radiation of around five thousand times the intensity humans can tolerate.



CORN SEEDLINGS are close to the pipe containing radioactive cobalt (above), and a variety of other crops are planted in concentric circles around this source (right). Normally the cobalt is several feet above the ground, but before humans can enter the field it must be lowered, by a remote-control cranking device at the edge of the field, below the surface of the ground. Among the results of this research has been the production of new strains of corn, one of which is similar to a primitive grass from which corn may have evolved.

Photographs from Brookhaven National Laboratory

THE USE OF ISOTOPES IN MEDICINE

It is making possible new research, new diagnoses, new methods of treatment in America's medical centers. And it is expanding every day.

WHAT is the role of the atom in medicine? Something that happened around the middle 1930's gives a good idea.

One of medicine's most basic concepts is that of metabolism, the process by which living things use and release energy. Until the middle thirties, medicine's ideas of metabolism were founded on the nineteenth-century thermodynamics of an eminent German physicist, Baron von Helmholtz. The body was like a machine. It consumed food, used it as a fuel. Its parts, like a machine's, wore out. They needed gradually to be replaced.

The concept was, inevitably, one of the most important in medicine. For the way in which medical science regards the processes of metabolism determines how medical science must regard a vast quantity of other phenomena. Medicine's idea of metabolism is a foundation on which a tremendous structure of thought and theory—and practice—must stand.

In the thirties, the thermodynamic theory of metabolism was proved inadequate.

MEDICAL SCIENCE has a powerful new weapon in its fight against disease: the use of atomic isotopes in research and treatment. Technique above is used in thyroid cases. Patient is fed radioactive iodine. Then, with Geiger counter, doctors detect and measure it as it concentrates in thyroid gland. Radioiodine traces trouble, often treats it.

IT began when Dr. Harold Clayton Urey discovered the hydrogen atom of atomic weight two: "heavy hydrogen," or deuterium. At Columbia University, where the discovery took place (before going to Columbia, Urey had for five years been in chemistry at Johns Hopkins; he now is at Chicago), investigators close to Urey began employing heavy hydrogen in a variety of research. In one direction, they used it in studies of metabolism.

They incorporated heavy hydrogen and heavy nitrogen into amino acids, which the body builds into proteins. Proteins comprise cells' enzymes; they are considered among the most integral, vital parts of cells. They are complex; one of the simplest protein structures known has a molecular weight of about 65,000, consisting of a vast number of components—amino acids. They are not thought of as being involved in a "fuel" process; they are regarded as being among the most permanent parts of cells.

Tracing the proteins and amino acids with heavy hydrogen and nitrogen, scientists employed Urey's earlier findings. Led by the late Rudolf Schoenheimer and David Rittenberg, they found that these relatively "permanent" factors in the body are being continually broken down and built up at the same

rate. They proved that there is a rapid, constant turnover of body substances. They learned that sometimes whole complex molecules at a time are being incorporated into proteins at an amazingly rapid rate. They concluded that within a few weeks, the majority of the protein of body tissues is made new.

They found, in short, that Helmholtz's thermodynamics, used as an explanation of metabolism, gave a false picture. The "machine" explanation of body functions, with its fuel-consumption and its gradual-wearout theories, was in error.

It is not hard to see how revolutionary such a discovery was, or how far-reaching its implications, once one understands how much of medical thinking depends upon an understanding of body processes. Slight changes in environment, slight changes in diet, drugs: the new proof of a rapid, constant metabolic process showed how tremendously, how immediately, they may affect human well-being.

Without "the atom," this knowledge would not be ours. Without "the atom," the new thinking which is occurring today in medicine would not be possible.

IT was probably inevitable that the great activity which such discoveries have brought about in medicine would be given the label "Atomic Medicine." But the term is not a good one. It is misleading, inaccurate, and best not used. The reasons for saying this may be helpful in explaining not only what "atomic medicine" *isn't*, but also what it *is*.

First there is the adjective "atomic". By now it is so hopelessly a part of the whole terminology of the times—from "Atomic Energy Commission" down through the corner grocer who advertises his "atomic service"—that probably no amount of protesting will succeed in substituting a better word. Let the grocer use it if he wills; but medicine and other research should find a more precise term.

"Isotopic" might be better; for it is the existence of isotopes, and man's ingenuity in discovering and using them, which makes such activities as the medical ones possible. An isotope is a form of an atom, differing from other forms of the same atom—other isotopes—in its weight. Commonly, for example, a hydrogen atom has a weight of one. Some hydrogen atoms, though, have a weight of two—the "heavy" hydrogen which Urey discovered. Although they are dissimilar in weight, different isotopes of a given element behave alike in chemical reactions. In a chemical sense, heavy hydrogen is just as truly and characteristically hydrogen as its more common brother.

Some isotopes of some elements are unstable; they decay. As they do so, they toss off certain of their parts—emit rays—which, when they bombard a Geiger counter, cause that instrument to click and thereby reveal their presence tellingly. These are "radioactive" isotopes. Isotopes which do not decay are called "stable." The presence of stable isotopes, too, can be detected, though not with a Geiger (a mass spectrometer is *their* detector: it sorts them out by their weights). Because their presence can be determined, both types of isotopes are useful in medical research. Because their rays attack human tissues, radioactive isotopes, properly administered, are often useful in treating those tissues which are diseased. Of such applications, more later.

But even the use of "isotopic" instead of "atomic" in the phrase "atomic medicine" leaves a misleading impression. It would imply, just as "atomic medicine" does, that "isotopic medicine" is some new field, some late arrival among medical specialties which has taken its place alongside—but distinctly apart from—other fields of medicine. Which is emphatically not so. The use of isotopes in medicine is a part of practically *every branch* of medicine, tied in with it intimately, and, in one way or another, revolutionizing its thought, its procedures, its future.

THE uses of isotopes in medicine may be divided, roughly, into two parts: (1) their uses in treating disease; and (2) their uses in medical research. Let us look at the first group first.

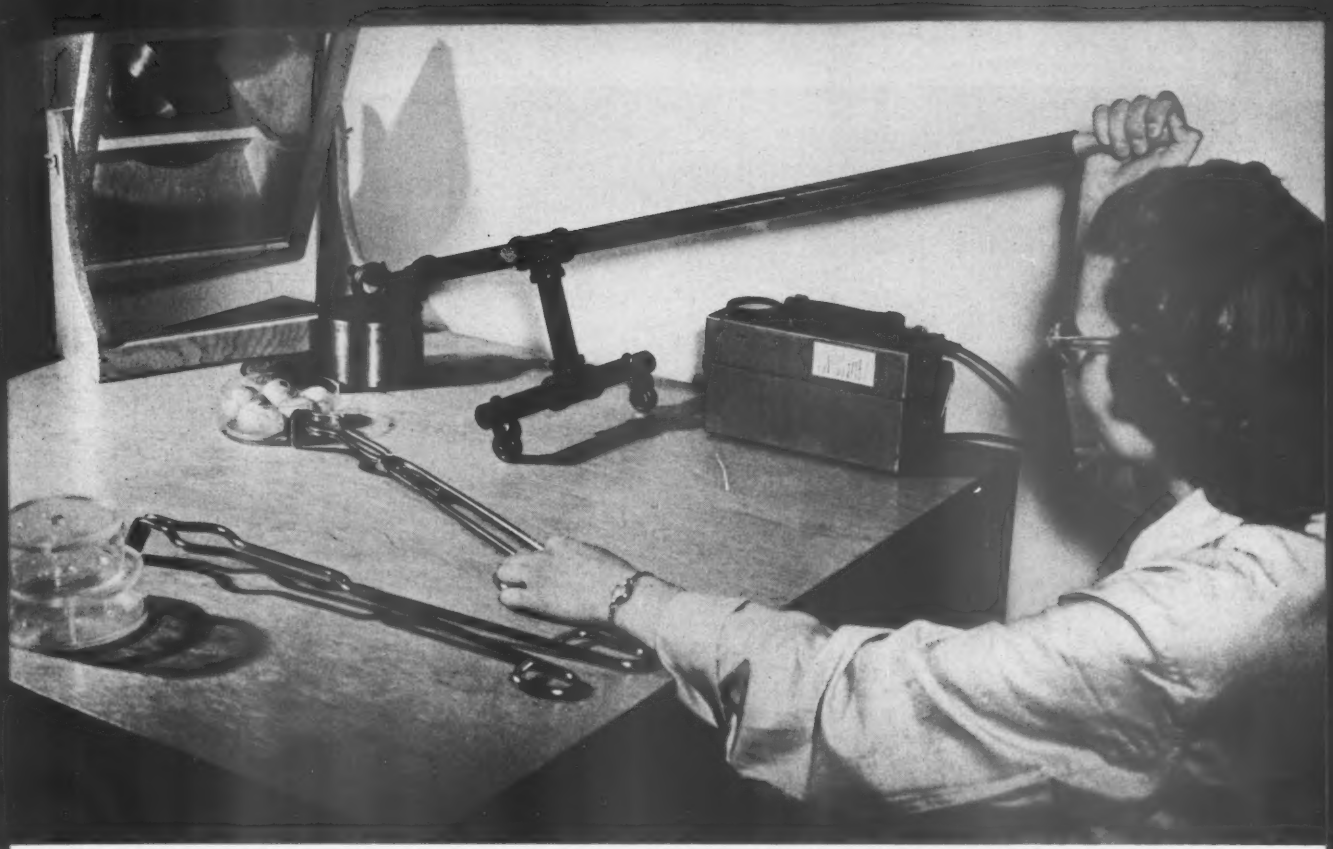
Certain individual elements have a strong affinity for specific parts of the human body. Iodine, for example: when iodine enters the body, it heads quickly, unerringly for the thyroid gland.

Suppose, when that gland suffers a disorder, iodine could be made to carry along, in its dash to the thyroid, some means for combating the disorder—rush a remedy to the precise point where it is needed. Particularly in cases where some other form of attack on the trouble—surgery, for instance—would be hazardous, such a "weapons-carrying" service on iodine's part would be handy indeed.

The radioactive isotopes of iodine are equipped to perform just such a func-

Jack Engeman

IN HOPKINS' HARRIET LANE HOME a pediatrician uses a Geiger counter to determine the activity of a young patient's thyroid gland. The boy has taken a dose of radioactive iodine; the Geiger will reveal its concentration in the thyroid.



YELLOW FEVER VIRUS has been injected into the chicken eggs in this photograph. Now, with remote-control tongs, the eggs are being placed near a source of radiation, located under the plug which the girl is lifting. This is part of research on the effect which radioactive rays have on the fever virus. Geiger counter, center right, measures radioactivity of the source.

tion. Being radioactive, they emit rays —rays which bombard body tissues. Being as thoroughly iodine as any other isotope of that element, they concentrate in the thyroid gland. They put their rays in front-line contact with the thyroid trouble. It would seem, then, that the radioactive iodine is in a peculiarly fine position to treat thyroid troubles which have previously been difficult, if not impossible, to handle.

And such has been the case. Take hyperthyroidism, for example: a dose of radioactive iodine is fed to the patient by mouth; when the thyroid is overactive, it receives at least one hundred times as much radiation as any other tissue of the body. The disease is thus being successfully combated with radioiodine in many hospitals. As early as 1948, Mayo Clinic doctors called radioiodine "an effective agent in treating patients with exophthalmic goiter whose physical conditions make other methods of treatment unduly hazardous." They reported "quite satisfactory" results in some eighty per cent of the cases treated.

Phosphorous, when first taken into the body, concentrates in the blood-producing centers: bone marrow, the spleen, lymph glands. This affinity is much like that of iodine for the thyroid, but not as great. The radioactive isotopes of phosphorous have proved effective in treating certain blood difficulties. They inhibit the production of blood cells, and have therefore been used with notable success in curbing polycythemia, a disorder in which there is over-production of red corpuscles.

Radioactive phosphorus has been tried on leukemia, also, but with less exciting results. Leukemia is a cancerous condition; it involves the over-production of white corpuscles, and therefore radiophosphorus seems applicable. It *has* brought relief to leukemia sufferers, but no cure.

THE radioisotopes' effects on cancers in general have so far not been spectacular. The two conditions mentioned above (with which radioisotopes have been successful as treatments)—hyperthyroidism and polycythemia—are noncancerous. Cancerous growths in the thyroid and in offshoots (metastases) of the thyroid throughout the body have not been treated as successfully by radioiodine; leukemia, as we have seen, is only palliated by radiophosphorus, not cured.

But there is hope. The trick is to find ways in which radioisotopes can be effectively concentrated in malignant tissue, and researchers throughout the country are trying to solve it. They are reporting —cautiously—some progress.

Radioactive cobalt produces radiations similar to those of radium. It is much cheaper than radium. It is, in many applications, more flexible than radium. But it must be placed mechanically, just as radium must be—and therefore has the same limitations that radium has when put into actual treatment use. It is useful in some cases—interstitial cobalt needles have been used to get at cancers of the uterus—but where the malignant growth is inaccessible from outside the body, radiocobalt can't be used.

Radioactive gold has been experimented with, also; but again there have so far been limitations. Fine particles have been suspended in solution and injected throughout cancerous masses near the surface of the body, and they have bombarded the diseased areas without entering into body processes. But such applications of colloidal gold

Hans Marz

USE OF ISOTOPES in medicine has made necessary the introduction of complex new techniques, involving precise instruments like this mass spectrometer built at Johns Hopkins especially for medical research. Mass spectrometers can sort out isotopes of an element by their weights and thus identify their presence in tissues. Dr. Theodore Enns, above, constructed this one for the Isotope Research Center at Hopkins, which provides for medical researchers the exact measurements necessary in their work. A diagram showing how this mass spectrometer works appears on Page 26.

are restricted to malignant growths which are not deeply buried within the body—and there is the rub.

The work is pushing forward, however. Radiocarbon is being incorporated into protein compounds and given to animals with cancers. Antibodies are being tried as transporters of radioactive materials. But until more is known about basic body processes—and isotopes will play an important part in this—many limitations may be expected to persist. Before more extensive clinical applications can be made, research must answer questions which now are stumbling blocks.

To provide the answers, the activity in research is great and growing.

WE have seen how investigation with isotopes proved new things about metabolism. That very basic work was made possible because the presence of isotopes, both the stable and the radioactive varieties, can be detected, and because therefore their progress through the body can be traced.

With tracer isotopes, medical scientists today are able to tag substances which are introduced into the body and follow them wherever they go: through different chemical states, through various physiological processes. They are able to provide precise answers to questions which, before the use of isotopes, could only be answered with speculation or, at best, approximations. Qualitative analyses and quantitative analyses are now possible where, until recently, only guesses could be hazarded.

How does the body use amino acids? They have been tagged with radioactive sulfur, fed to rats, and then traced to the tissues of the body to which they travel. Their progress has been studied in healthy rats and compared with their progress in diseased rats. The body tissues have been analyzed to find what form the sulfur has taken within the animals: how much has been used in proteins, how much has not combined, and so on.

How does the body use iron? Radioactive iron, iron 59, has been fed to dogs, and researchers have found that, unlike most other elements used by the body, iron is usually absorbed in very small quantities from food, only as needed by the body, and that iron which the body already has is used over and over again: as red blood cells break up and are replaced, they turn over their iron to the new cells for re-use.

What happens to agents which produce cancer? Cancer-producing compounds—carcinogens—are labelled with radioactive carbon; they are made to produce cancers in rats; the cancers themselves are analyzed, and so are other tissues of the rats' bodies. The distribution of the carcinogens is easily and accurately determined, because the presence in tissues of the radioactive carbon isotopes clearly reveals their presence wherever they may be.

Thus, as tracers, isotopes are being employed in a wide variety of research projects. There are many more uses to which they can, and will, undoubtedly be put, as more and more medical scientists turn to them and learn to put them to use.

DR. UREY, he who discovered heavy hydrogen, has furnished an intriguing example of how versatile are the services which isotopes can perform for the scientist. Dr. Urey conceived the idea of figuring out what temperatures prevailed at the time when certain prehistoric animals died on this earth. It is hard to imagine a more difficult project that a scientist might set up for himself: determining how hot or how cold it was at a given instant in the earth's history thousands of years ago. But using stable isotopes, Urey was able to carry out his project handily. Here is how he did it:

Oxygen, which is in the systems of all living things, has three stable isotopes. Their atomic weights are sixteen (the most common oxygen isotope), seventeen, and eighteen. Each isotope can be distinguished from the others by weight—and its quantity measured—by means of the mass spectrometer.

Urey knew that the ratio between these oxygen isotopes deposited in the carbonate structures of a living thing is a function of the temperature of the environment in which the thing lives. So, with a mass spectrometer, Urey analyzed the quantity of oxygen 18 which existed in fossils of prehistoric animals, comparing it with the quantity of the other isotopes of oxygen in the animals. Since such a relationship varied with the temperature at the time the animals lived—and was "frozen" for all time at the moment the animals died—Urey could accurately tell how warm it was at the time of the animals' deaths.

Such an experiment would not have been attempted without isotopic knowledge and an ability to use it. Similarly, in medicine, research which until recently was impossible now becomes com-

Continued on Page 26

THE SKILLED HANDS and dexterous fingers of a medical technician translate a scientist's idea regarding effects of radiation into an actual test of his prediction. Here virus particles are being injected into a chick embryo. Later, as in the photograph on Page 18, the embroy will be irradiated by isotopic sources as part of a broad investigation of the effects of radiation and of disease.

NEARLY EVERYONE'S USING THE ATOM

Already it's doing so many jobs in power, research, and industry that the atom looks like man's greatest boon since fire.

FIVE years after the world woke up and found itself in the Age of Radiation (the term is David Lilienthal's), it is surprising to see how many of the extravagant prophecies made then have been or are being fulfilled. We cannot, and possibly never will, drop an atomic pill into the gas tank of our automobile and have it run for five years. But in power, nevertheless, we have made astonishing progress; in industry we already have practical applications; and in research radioactive elements have proved even more of a boon than we guessed.

Radioactive isotopes are growing increasingly useful to almost all forms of research, most noticeably industrial, agricultural, and medical. Simply, a radioactive isotope is one form of a given element which emits particles of nuclei. Radioactive table salt, for example, will look and taste and chemically appear exactly like regular table salt, the only difference being that it contains one form of an element (i.e. one of its isotopes) that also emits radioactive particles.

These isotopes appear naturally in numerous forms, and they are providing a variety of useful information. All living things, for example, contain a radioactive carbon isotope, called carbon 14 because extra neutrons give it an atomic weight of 14 (as opposed to 12 for the regular stable carbon atom). Plants and animals absorb this through life; at death the process stops, the isotopes decay and gradually lose their radioactivity. This carbon 14 loss is very slow, taking thousands of years. It proceeds at a definite rate which has been determined and can be charted.

By measuring the carbon 14 of Indian relics found in New York state, archaeologists last September made the astonishing discovery that Indians had lived there as early as 3000 B.C. Previous estimates had placed the first tribes a little after the time of Christ. Archaeologists expect to date with greater accuracy such things as Egyptian mummies and pre-historic animals and to test the authenticity of religious relics of the Crucifixion and the saints. Hopkins' Professor William F. Albright has been asked to test the technique in his archaeological expeditions to the Near East.

MOST research, however, is conducted with artificial isotopes. Among the several production methods, by far the most efficient is the use of the atomic pile, notably (so far) the one operated by the Atomic Energy Commission at Oak Ridge, Tennessee. Here radioisotopes are manufactured by three general methods: splitting fissionable uranium atoms to form new elements which are radioactive themselves; attaching neutrons to stable isotopes to produce heavier isotopes; and altering the electrical charge of an atom's nucleus to form an isotope of a different element. The resulting radioisotopes, which now are relatively plentiful, are purchased from the Atomic Energy Commission for research or for direct radiation use.

These radioisotopes acting as tracers are making important contributions to agricultural research. Primary among these is the understanding of the basic plant process of photosynthesis. We know that plants absorb carbon dioxide from the air and with the aid of sunlight convert it into sugars and starches. But we do not know *how* the process works.

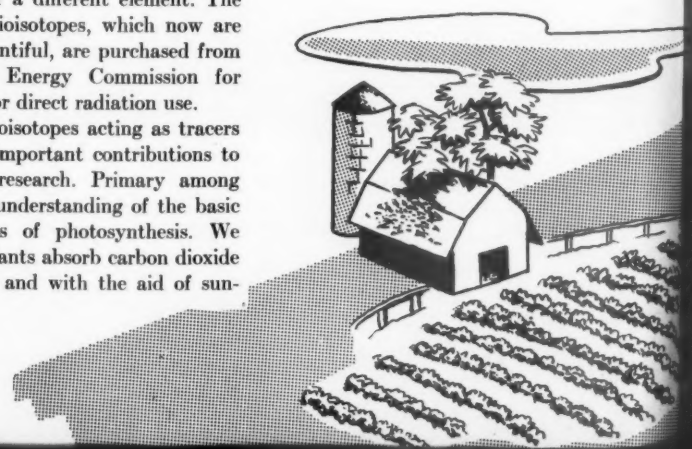
Research men are surrounding plants with carbon dioxide gas which contains a small amount of the radioactive carbon 14. With the help of Geiger counters, they can trace its process through the plant system. They hope thus to find when and how the change occurs, information which may lead to synthetic production of foods and the solution of one of our greatest economic and social problems.

Hopkins' McCollum-Pratt Institute is an international center for research on trace elements, tiny amounts of metals, newly discovered, which vitally affect the health of plants and animals. Radioactive isotopes are invaluable as tracers to show the distribution of these metals within the plants (see *The Johns Hopkins Magazine*, May 1950).

Fertilizers, a heavy farm expense of which we have known surprisingly little in the past, are being studied with the assistance of isotopes. Already we have practical results. Experiments have shown, for example, that potatoes use phosphates all through the season and that continued application of fertilizer would be useful. Corn, tobacco, and cotton, however, use it only in the early stages of growth, suggesting that phosphate application after the middle of the season is a waste of money.

The isotopes may be followed not only through plants but into the animals which graze on test fields. Recurrent anemia in cattle is being stamped out as a result of tests showing how cattle are affected by cobalt.

HOPKINS' oceanographers investigating the absorption of plant nutrients in the Chesapeake Bay have added Geiger counters to their equipment. Radioactive isotopes in the water are watched to learn which elements, in



what amounts, are held in colloid by the silt.

Some of the most dramatic possibilities are in the medical field. Here isotopes are working both as research aides and as physical cures (see page 10).

Small portions of certain radioactive elements may be given directly to animals without harm. Mosquito larvae bathed in radioactive phosphorus stay radioactive all their lives and their presence can be detected with Geiger counters. By using small test groups, scientists are learning how long mosquitoes live, the rate and direction in which a colony moves, information which should make insect control far more effective. Similar treatment of birds may increase information about migration.

MORE abstract laboratory research is getting a big assist from the isotopes. Chemists at Hopkins use them as tracers to observe the mechanism of chemical reactions and to study problems in the diffusion of gases into solids. They also are looking at the isotopes themselves to learn the properties of radioactive nuclei: how they are created, their shape, and their composition.

Radioactive isotopes are being used extensively by industry. At Ford plants, the awkward X-ray method for testing the structure of parts such as tubes is being replaced: a small capsule of radioactive material, which can be inserted within the tube, checks much more efficiently. The problem of reading the height of molten metal in a foundry has been simplified: simultaneously a radioactive source is moved slowly up one side of the foundry and a counter up the other; the level can be determined very accurately by noting the sudden change in count when the apparatus reaches the top of the liquid.

Some steel plants have tried adding radioactive sulphur to their regular sulphur before mixing it with iron. In later stages they can easily test the proportion of the alloy with a Geiger counter. The same technique has been advanced in electroplating so that the Geiger controls switches which automatically correct the concentration of materials.

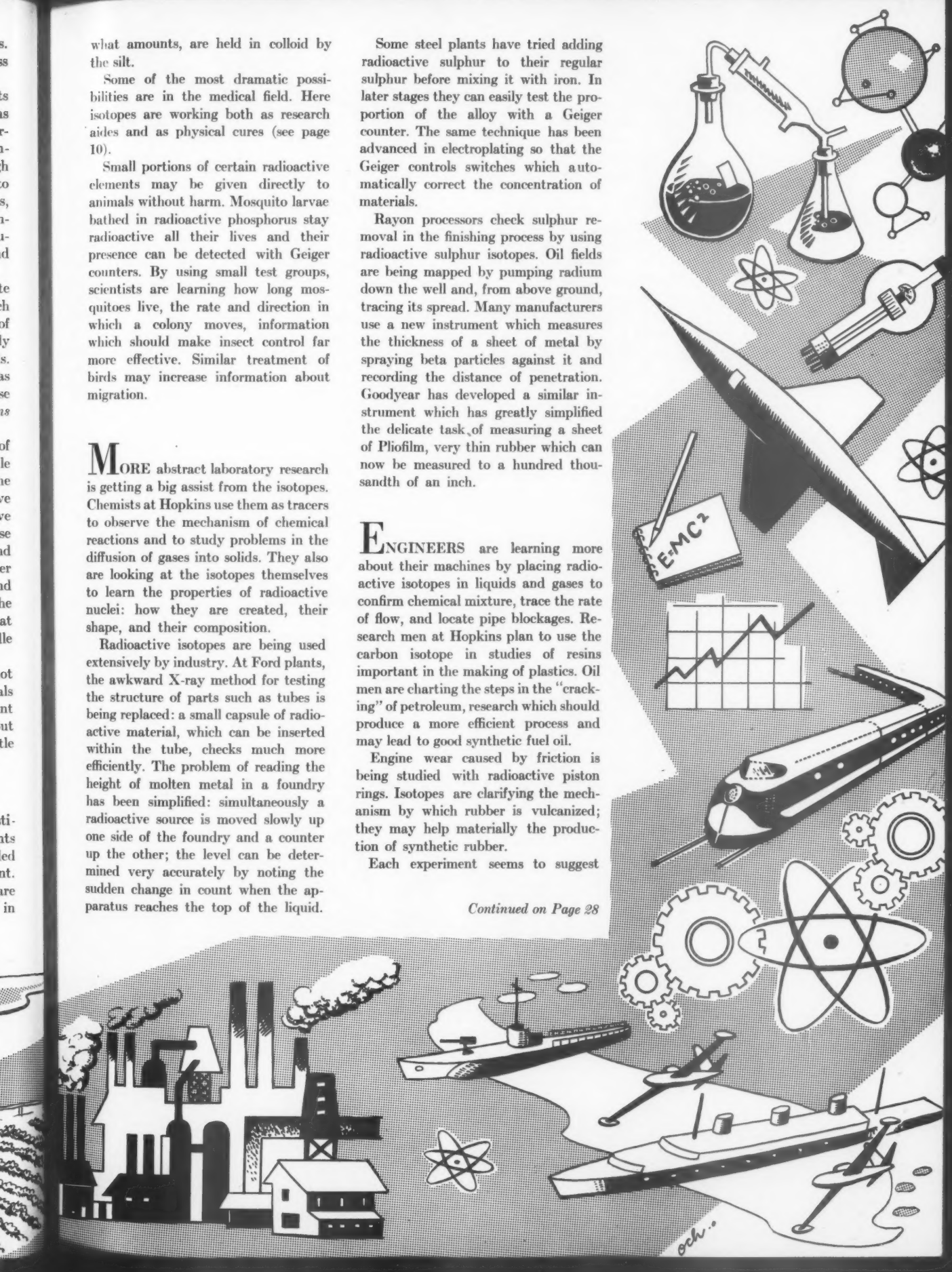
Rayon processors check sulphur removal in the finishing process by using radioactive sulphur isotopes. Oil fields are being mapped by pumping radium down the well and, from above ground, tracing its spread. Many manufacturers use a new instrument which measures the thickness of a sheet of metal by spraying beta particles against it and recording the distance of penetration. Goodyear has developed a similar instrument which has greatly simplified the delicate task of measuring a sheet of Pliofilm, very thin rubber which can now be measured to a hundred thousandth of an inch.

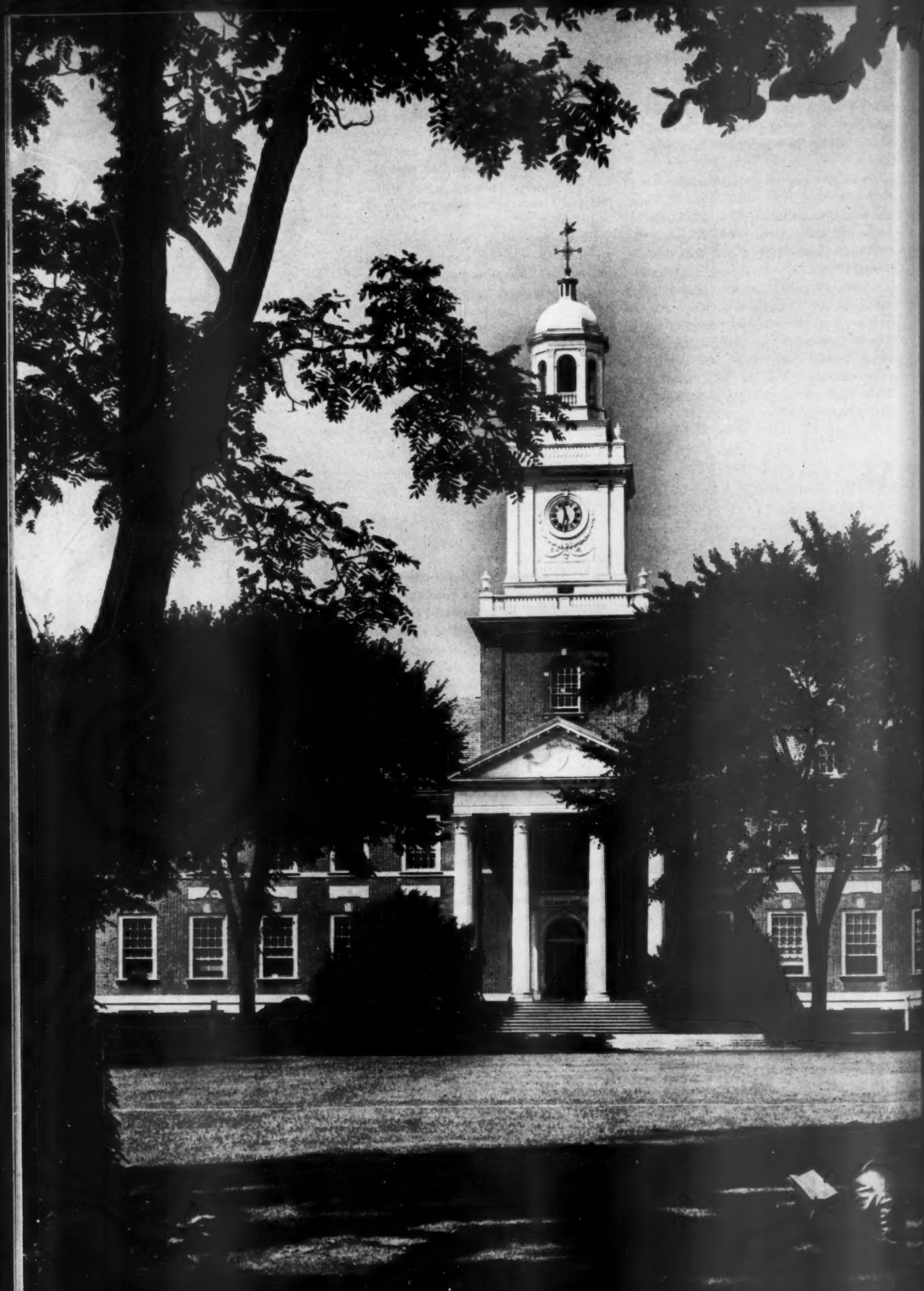
ENGINEERS are learning more about their machines by placing radioactive isotopes in liquids and gases to confirm chemical mixture, trace the rate of flow, and locate pipe blockages. Research men at Hopkins plan to use the carbon isotope in studies of resins important in the making of plastics. Oil men are charting the steps in the "cracking" of petroleum, research which should produce a more efficient process and may lead to good synthetic fuel oil.

Engine wear caused by friction is being studied with radioactive piston rings. Isotopes are clarifying the mechanism by which rubber is vulcanized; they may help materially the production of synthetic rubber.

Each experiment seems to suggest

Continued on Page 28





NEWS at Johns Hopkins

A digest of developments at the University and Hospital in recent weeks

RAPID expansion in many departments brought an unusual number of changes to Johns Hopkins last month. When finally totalled up, the undergraduate freshman class turned out to be thirteen per cent larger than that of last year. The Institute for Cooperative Research had outgrown its St. Paul Street quarters and leased additional laboratories in suburban Roland Park. The School of Nursing was centralized in modern facilities of the Main Residence of the Hospital. Jenkins Hall, housing the department of biophysics, was dedicated at Homewood, and the Robert F. Guy Memorial Walk was nearing completion. A complete graduate school was acquired as Hopkins took over the School of Advanced International Studies in Washington.

Meanwhile, the citizens of Baltimore are voting this month on a proposed law of great importance to medical research at Hopkins and the University of Maryland. If passed, the law, sponsored by antivivisectionist groups, would prohibit doctors from using in medical research stray dogs due to be destroyed in the city pound.

Thirteen of Europe's leading mathematicians delivered a series of lectures at Homewood, discussing their latest investigations in the field of mathematics. Dr. Frank M. Burnet, F.R.S., director of the Walter and Eliza Hall Institute and professor of experimental medicine, Melbourne, Australia, visited the University under the Herter Lectureship Foundation. He delivered three lectures on "Some Biological Implications of Studies on Influenza Viruses."

Weber, J H U Illustrations

JENKINS HALL, new building for department of biophysicists at Homewood, was dedicated last month. Honorary degrees were awarded to four eminent biophysicists at the exercises. (Article on this page.)

Four Saturdays' play gave the Jay football team one win and one tie against two losses. The soccer team, with only two varsity veterans, came up surprisingly to win two of its first three games. And the crosscountry team took its opening meet against Gallaudet. The champion lacrosse team was still collecting honors: two members, Bunting and Sandell, were named to the first All-America team of the United States Lacrosse Association, and all the squad members were included in the second, third, or honorable mention ratings.

Jenkins Hall

"Curiosity, the spirit of adventure, the desire to assist one's fellows are the motives which stimulate human progress. . . You and your distinguished husband have had an insatiable curiosity that lured you together to distant regions of the globe, there to

learn of other cultures, and there to satisfy your love of humankind by understanding the ways and thoughts of men and women of other nations. And so it was appropriate that you should wish to perpetuate the memory of your husband through this institution which will foster exploration of the frontiers of knowledge and thus benefit all men and women."

Thus did President Bronk, addressing Mrs. Thomas Courtney Jenkins, pay tribute last month to the donor of the new biophysics building at Homewood which bears her husband's name, at the building's dedication.

The dedication of Jenkins Hall was accompanied by an impressive program for which five of the world's most eminent biophysicists visited the University and delivered a series of important lectures. They were Dr. A. V. Hill, Nobel Prize winner associated with the Royal Society of London; Dr. E. Newton Harvey, professor of physiology at Princeton; Dr. E. D. Adrian, professor of physiology at Cambridge University, England, and Nobel Prize winner in 1932; Dr. Herbert S. Gasser, director of the Rockefeller Institute and 1944 Nobel Prize winner; and Dr. Francis O. Schmitt, professor of biology at Massachusetts Institute of Technology.

Dr. Gasser had previously received (in 1947) the Doctor of Science degree from Johns Hopkins. At the Jenkins Hall dedication, the degree was awarded to the others.

One of the chief aims of the Department of Biophysics is to produce scientists with the rare combination of sufficient training in both biology and physics to prepare them for biophysical research. There is a great need now, Dr. Bronk stated, for men who can bridge "the barriers of understanding which separate the fields of knowledge."

International Studies

The School of Advanced International Studies, in Washington, has become a graduate school of the Johns Hopkins University. It will remain in Washington, in order to take advantage of the great research facilities available in the nation's capital.

Since 1944 the School has conducted post-graduate education and training in foreign affairs under the sponsorship of the Foreign Service Educational Foundation. The Foundation has transferred to Hopkins the buildings, library, and equipment of the School and will continue to contribute to its support. Further support has been provided by a grant from the Carnegie Corporation of New York.

TOOLS FOR RESEARCH are designed and engineered in this machine shop at the Hopkins Institute for Cooperative Research. Carrying through a scientist's idea from rough drawings to finished equipment, the shop is meeting the growingly complex needs of modern research by producing precision instruments for Hopkins investigators in all branches of the University.

The aim of the school has been, and will remain, to train unusually qualified college graduates in the field of international affairs, preparing them for posts in government, private enterprise, and the professions. It will not duplicate the work of the University's Walter Hines Page School of International Relations, which is primarily a graduate research institute.

The program of the School has been developed in such a way as to combine the highest academic standards with a practical approach to present problems. The curriculum includes specialized lecture courses, seminars, and supervised research in such fields as United States foreign policy, diplomacy, foreign business and trade, and international relations, law and economics. Detailed studies are made of individual geographic areas, and intensive work in modern foreign languages is included in the regular curriculum.

In a joint statement, President Bronk and Congressman Christian A. Herter, president and chairman of the board of the Foreign Service Educational Foundation, and chairman of the board of the School of Advanced International Studies, said:

"It is our firm conviction that under the new arrangements the School will fill the need for unusually able and thoroughly trained individuals to meet our heavy international responsibilities even more effectively than has been possible with the limited means heretofore at the School's disposal.

"Substantial mutual benefits to the University and the School will certainly result from the association. The University will obtain an established school in the vital field of international affairs which has a splendid record of accomplishment and high scholastic standards, together with a complete operating plant located in the strategic center of world affairs.

"The merger with the Johns Hopkins University will permit the use of all those facilities which only a great university possesses. These, with the increased financial stability afforded by the grant from the Carnegie Corporation, will enhance the ability of the School to attract the highest calibre of faculty and students and to broaden the scope of its curriculum and research."

For Children's Care

Henriette van den Berg, who graduated from the Hopkins School of Nursing in the class of 1899, specialized in obstetrical care. Her excellence in the field led to special-duty work with the family of Mrs. Henry W. Bagley. There,

Blakeslee-Lane

Picture at left shows an ICR-designed-and-built hydrogen liquefier undergoing final check-up; the Institute has produced these not only for Hopkins use but also for other laboratories here and abroad. Two photos at right show ICR machinists at work on precision parts for X-ray camera to be used in Hopkins metallurgy studies. ICR machine shop specializes in close-tolerance work required in research, yet manages to keep costs at a moderate level. It is located in ICR's off-campus headquarters at 1315 St. Paul St.

except during a brief period of service with the Army Nurse Corps in World War I, she remained to care for the children.

Last year, prompted by Miss van den Berg's devotion and care, Mrs. Bagley established a $100,000 endowment in the Hopkins' Harriet Lane Home, the Hospital's pediatric division. Now, under funds provided by the Henriette van den Berg Endowment, children suffering from functional disorders such as metabolic diseases, endocrine dysfunctions, and similar ailments can receive the most modern care and treatment.

Income from the endowment pays for the long and costly treatments which are necessary in caring for children having such diseases. And ultimately, the principal of the fund will be applied toward the construction of a new pediatric division which will have a special ward for the care of the diseases. There, a bronze plaque, soon to be temporarily located in the Harriet Lane Home's main corridor, will be permanently placed.

Bright X-Ray

A new X-ray screen that produces light 150 times as bright as previous X-ray screens is now being used on patients at Johns Hopkins. The screen, developed by Westinghouse, is called an electronic fluoroscope. It enables radiologists to conduct X-ray examinations without darkening the room.

The fluoroscope is part of the equipment in Hopkins' new Radiology Building, completed last spring. Last month special ceremonies were held in the building to honor two eminent Hopkins radiologists, the late Dr. F. Harry Baetjer, radiologist-in-chief from 1914 until 1933, and Dr. John W. Pierson, who held the position from 1933 until 1946, when he was succeeded by Dr. Russell H. Morgan. W. Frank Roberts, president of the Hospital Board of Trustees, unveiled portraits of the two men.

The new X-ray screen, Dr. Morgan feels, will be a great aid in teaching as well as in diagnosis. Students will be able to see X-ray film of cancer of the stomach, ulcers of the stomach and duodenum, pneumonia, congenital heart disease, and other ailments.

Previously, X-ray views were dim; the safety of the patient would be endangered if there had been an increase in the X-ray and more light. The new fluoroscope converts low-light images into electron images. The electrons are accelerated inside an evacuated tube and impinged on a fluorescent screen, consequently producing greater light.

Radiology units in the Hospital had previously been located in the Surgery Building. The new structure has six diagnostic and three therapy rooms and is designed so that patients may go directly from dressing rooms into X-ray rooms without entering corridor areas.

Recent Books

JOHN J. HANLON, M.P.H. '42: *Principles of Public Health Administration.*

NOBUTKA IKE, fac. '48–'49, Ph.D. '49: *The Beginnings of Political Democracy in Japan.*

WILBUR R. JACOBS, g. '46: *Diplomacy and Indian Gifts.*

J. WEBSTER MERRITT, M.D. '33: *A Century of Medicine.*

WILDER PENFIELD, M.D. '18 (and T. Rasmussen): *The Cerebral Cortex of Man: A Clinical Study of Localization of Function.*

JOSEPH WORTIS, fac. '38–'39: *Soviet Psychiatry.*

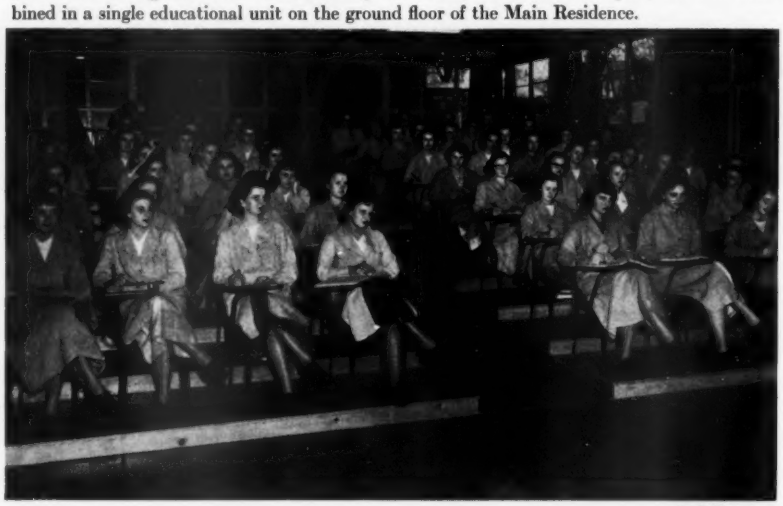
Drama Awards

Prizewinners have been announced in two nationwide contests of the Johns Hopkins University. Ken Parker has won this year's Victor Frenkil Prize for original television scripts. H. Bried, of California, has taken the Theodore Marburg Prize for three-act plays.

"The Remodeling of Sylvia" is the comedy which won the $100 prize for Mr. Bried. The Marburg Prize Play must be an original unproduced drama.

Jack Engeman

STUDENT NURSES learn anatomy in one of the new laboratories recently provided for the School of Nursing. Facilities which formerly were scattered over the Hospital are now combined in a single educational unit on the ground floor of the Main Residence.



Jack Engeman

CLASS IS HELD in the new auditorium and lecture room. Several smaller lecture rooms and two conference rooms are provided for the Nursing School. This year's seventy-eight first-year students constitute the largest class since World War II.

The late Mr. Marburg established the award as a means of finding and giving recognition to promising young playwrights. Mr. Bried's play will be produced by the Johns Hopkins Playshop in February.

The Frenkil TV contest was established two years ago to encourage young writers to experiment with new television techniques. Mr. Parker's script, "A Cup of Tea," led fifty-six other entries to take the $150 prize. Dealing with the adventures of two women and a gypsy tea-leaf reader, the play will be televised by the Playshop.

Nurses' Center

A new education unit has been opened at the Johns Hopkins School of Nursing. For the first time, all of the teaching units of the School have been coordinated in one central location on the ground floor of the Main Residence. Previously, students used classrooms on the fourth floor of the Surgical Building (which is now being razed) and laboratories in various buildings of the Johns Hopkins Medical Institutions.

In the new unit are two conference rooms, a large auditorium seating one hundred persons, and a second lecture room accommodating fifty. The former nurses' dining room has been transformed into a sixteen-bed teaching unit for instruction in nursing arts, and there is a smaller, six-bed room for the same purpose. Nursing aides are also taught in the nursing-arts classrooms.

In addition, there are two modern laboratories: one for anatomy and microbiology and the other for chemistry and physics. There is also a special classroom for nursing dietetics. Offices for instructors are located adjacent to the classroom area.

The Faculty

● *President Detlev W. Bronk* has been elected to the Board of Trustees and the Committee on Scientific Policy of the Sloan-Kettering Institute.

On September 28 Dr. Bronk spoke on "Science in a Democracy" at the seventy-fifth anniversary celebration of the Connecticut Agricultural Experiment Station.

He presided at the semi-annual meeting of the National Academy of Sciences, held in Schenectady from October 9 through 12. Dr. Bronk was elected president of the Academy last spring.

● *Among members of the Board of Trustees*, Walter S. Gifford has been appointed ambassador to Great Britain, succeeding Lewis W. Douglas who resigned effective November 1.

Robert W. Williams has been nomi-

A SIXTEEN-BED WARD, well equipped, has been created to serve as a training laboratory in the nursing arts.

Jack Engeman

nated by President Truman as a member of the United States Maritime Board.

● *In the Faculty of Philosophy*, Howard E. Cooper, professor of accounting, has been appointed a member of the committee of research of the National Association of Cost Accountants.

Terrell L. Hill has been appointed lecturer in chemistry.

Kemp Malone, Caroline Donovan Professor of English Literature, has been knighted in the Order of Dannebrog by King Frederick IX of Denmark to honor him for his research and writing on subjects of Danish origin.

Henry Carrington Lancaster, James M. Beall Professor of French Literature, was awarded the degree of Doctor of Humane Letters by Tulane University.

Robert Larimore Pendleton, professor of tropical agriculture and soils, has been awarded the David Livingstone Centenary Medal of the American Geographical Society for work of special distinction in the field of geography in the Southern Hemisphere.

The late Charles K. Swartz, former professor of geology, has been honored by the naming of a newly identified mineral in the uranium group. It has been named Swartzite.

● *At the School of Hygiene and Public Health*, William H. F. Warthen, lecturer in public health administration, has been chosen "the outstanding citizen of the year" of Towson, Md.

● *At the Hospital*, the following appointments have been made:

Eugene D. Lyon, dental surgeon-in-charge; B. Lucien Brun, honorary consultant, dentistry.

Edmund R. Novak, gynecologist OPD (Out-Patient Department).

Abraham Genecin, Milton Kress, Ross L. McLean, Philip F. Wagley, Harold Zheutlin, physicians; Philip A. Tumulty, director, medical clinic OPD; Paul E. Carliner, N. S. Davidson, physicians OPD allergy clinic.

J. William Dorman, obstetrician; William L. Hartmann, obstetrician-in-charge OPD.

Roy O. Scholz, ophthalmologist.

John F. Crigler, Jr., Crosby Deacon, Lytt I. Gardner, pediatricians and pediatricians OPD; Roy M. Baker, Roy B. Howarth, Anthony Perlman, Marrion U. Scott, pediatricians OPD.

Frederic G. Worden, psychiatrist; Jacob H. Conn, J. Martin Myers, psychiatrists OPD.

Richard B. Hancett, radiologist.

Jacob C. Handelsman, Alan C. Woods, surgeons and surgeons-in-charge OPD; Milton Edgerton, surgeon (plastic) and surgeon (plastic) OPD; Richard C. Clay, William E. Grose, Jr., Edward S. Stafford, surgeons OPD.

Robert Y. Risher, neurosurgeon, neurosurgeon OPD.

Joseph M. Menning, urologist.

In the Diagnostic Clinic, the following appointments have been made: Abraham Genecin, medicine (alternate); John T. Howard, physician, gastroenterology; Edward L. Suarez-Murias, neurology; I. Ridgeway Trimble, surgery; A. Earl Walker, neurosurgery.

W. Arthur Purdum, chief pharmacist at the Johns Hopkins Hospital and professor of hospital pharmacy at the University of Maryland, has been elected a member of the council of the American Pharmaceutical Association for a three-year term.

● *In the School of Engineering*, Albin I. Johnson, formerly of the University of Toronto, has been named assistant professor of chemical engineering.

T. Benjamin Jones has been promoted to associate professor of electrical engineering.

Harris & Ewing

SCHOOL OF ADVANCED INTERNATIONAL STUDIES has become a graduate school of the University. Located at 1906 Florida Ave., N.W., Washington, the school adds to Hopkins a ready institute for high-standard instruction in foreign affairs.

● *At the Applied Physics Laboratory*, the following men have been appointed to the staff: Charles I. Beard, formerly with the field research laboratory of the Magnolia Petroleum Co.; Fred K. Elder, Jr., formerly assistant professor of physics at the University of Wyoming; and Robert W. Hart, formerly instructor of physics at Catholic University.

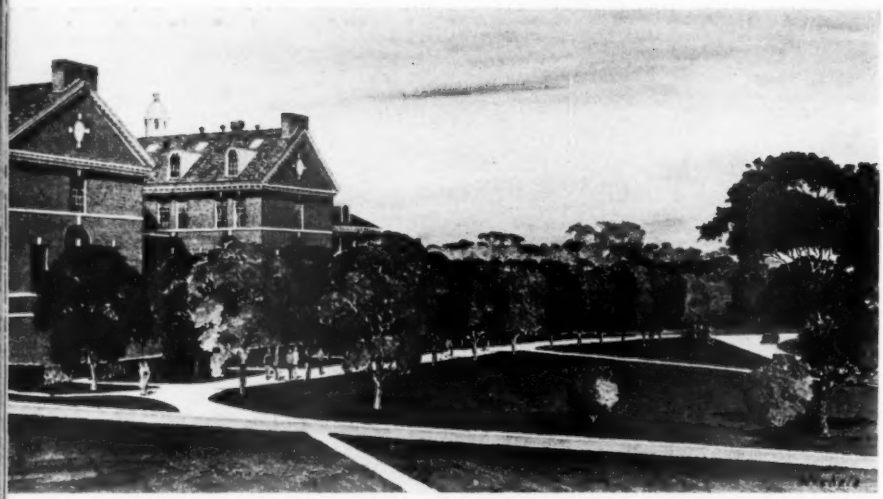
Edward C. Stevenson, supervisor of Project Bumblebee Guidance, has returned to the University of Virginia as professor of physics.

Alumni Notes

The late William S. Bayley, B.A. '83, Ph.D. '86, has been honored by the naming of a newly identified mineral in the uranium group, to be called Bayleytite.

Edwin G. Conklin, Ph.D. '91, LL.D. (hon.) '40, has retired from the Academy of Natural Sciences of Philadelphia after serving fifty years as vice president and thirteen years as trustee.

Edwin W. Bowen, Ph.D. '92, has re-



THE ROBERT H. GUY MEMORIAL WALK at Homewood is now near completion. Shown above is architects' drawing of the finished walk. To be lined with trees and privet hedges, it replaces the old parking lot (below) north of Remsen and Mergenthaler Halls.

Weber, J H U Illustrations

tired as professor of Latin at Randolph-Macon College after fifty-six years on the staff.

Ross G. Harrison, Ph.D. '94, fac. '97, has been reelected a trustee of Science Service.

J. Albert Chatard, g. '98–'99, M.D. '03, fac. '05–'23, has received Loyola College's Carroll Medal, awarded annually to an outstanding alumnus.

Maurice R. Schmidt, B.A. '06, Ph.D. '09, retired in May as general superintendent of the Whiting (Ind.) refinery of the Standard Oil Company of Indiana. He had been with the company since 1917.

George W. Vinal, g. '06–'07, chief of the National Bureau of Standards Division of Electrochemistry and dean of the NBS staff, has been awarded the Edward Goodrich Acheson Medal and Prize by the Electrochemical Society. The award is given biennially for the most outstanding contribution in the fields of activity fostered by the society.

Harold H. Bender, Ph.D. '07, Pyne professor of Indo-Germanic philology at Princeton University, has retired after forty-one years at Princeton.

Nathaniel E. Loomis, Ph.D. '11, vice-president and a member of the board of directors of the Standard Oil Development Company, has retired after thirty-two years with the company.

Drew W. Luten, M.D. '11, has been appointed associate professor emeritus of clinical medicine at Washington University School of Medicine. He has been on the staff since 1915.

Arthur W. Allen, M.D. '13, chairman of the Board of Regents of the American College of Surgeons, has been appointed an honorary fellow of the Royal College of Surgeons of Edinburgh.

The Section on Experimental Medicine and Therapeutics of the American Medical Association has established a lectureship in honor of the late George R. Minot, '14–'15.

Virgil B. Sease, Ph.D. '17, retired in June after thirty-three years of service with E. I. du Pont de Nemours & Co. He was director of the development section of the photo products department.

Colin Mackensie Mackall, Ph.D. '20, has become professor emeritus of chemistry at George Washington University after serving twenty-five years there.

Gordon S. Seagrave, M.D. '21, known as the "Burma Surgeon" has been held in jail since August 20 when the Burmese government arrested him on a charge of aiding the rebel Karen tribesmen in their fight for autonomy. Recently the charge was changed from disturbing the public order to the much graver one of high treason.

Gordon H. Scott, g. '22–'23, has resigned as chairman of the Anatomy Department of the University of North Carolina to become dean of the college of medicine.

Merle A. Tuve, fac. '24–'26, Ph.D. '26, D.Sc. (hon.) '50, has been awarded the Howard N. Potts Medal by the Franklin Institute. He was honored for his leadership in the development of the proximity fuze, completed at Hopkins' Applied Physics Laboratory during World War II.

Louis L. Jaffe, B.A. '25, formerly dean of the Faculty of Law at the University of Buffalo, has joined Harvard Law School as professor of law.

J. Leon Shereshefsky, Ph.D. '26, of Howard University, has received a grant-in-aid from the State Department to serve for one year as visiting professor of physical chemistry at the Hebrew Institute of Technology, Haifa, Israel.

Leon Howard, Ph.D. '29, resigned last June from his post as Morrison professor of English at Northwestern University to become professor of English at the University of California in Los Angeles.

George M. Halsey, B.E. '31, has been named director of manufacturing in the Glidden Company's chemical and pigment division.

Cosmo G. Mackenzie, B.A. '32, D.Sc. '36, fac. '39–'43, '46, has been named professor and head of the department of biochemistry at the University of Colorado School of Medicine.

John T. Rettaliata, B.E. '32, Dr. Eng. '36, dean of engineering at the Illinois Institute of Technology, has also been named vice president for academic affairs.

Karl J. Arndt, Ph.D. '33, has been appointed professor and chairman of the German department at Clark University.

Abram Bergson, B.A. '33, has been named professor of economics at Columbia University.

Irvin Levin, B.S. '35, has been appointed head of the new Biophysical Instrumentation Department of the Army Medical Department Research and Graduate School, Washington, D.C.

Mitchell Gratwick, M.D. '36, fac. '37–'38, is the new headmaster of the Horace Mann School, the Bronx, N.Y.

Howard J. Curtis, fel. '38–'40, fac. '40–'41, has been appointed chairman of the biology department at Brookhaven National Laboratory.

Paul E. Mattman, M.D. '41, fac. '42–'43, has been appointed assistant professor of medicine at the Wayne University College of Medicine. He will also be visiting consultant at the Dearborn Veterans' Hospital.

James K. Shafer, M.P.H. '43, has been appointed assistant chief of the division of venereal disease of the Public Health Service.

Margaret Mary O'Connell, D.Ed. '50, has been named president of the College of Notre Dame of Maryland.

Deaths

(*Dates are 1950, unless otherwise noted.*)

Dr. Thomas Richardson Brown, trustee of the University and associate professor emeritus of medicine, died September 26 at the age of seventy-eight. Internationally known expert on internal medicine, Dr. Brown had been associated with Johns Hopkins more than sixty years.

He received his bachelor's degree from Hopkins in 1892, took two years of postgraduate work, and then entered the first class of the School of Medicine, graduating in 1897. He spent several years in medical charge of Dr. Howard Kelly's sanatorium and then went into private practice, but he remained on the teaching staff of the University.

Dr. Tom Brown was long one of the leaders of medicine. Starting with a discovery (while still a student) of a method for diagnosing trichinosis, he published more than one hundred scientific reports and articles. His famous patients included President Wilson, Charles Evans Hughes, Daniel Guggenheim and members of the du Pont family, as well as many famous baseball players of whom he was an avid fan.

Dr. Brown founded, and for many years directed, a department of digestive diseases at Johns Hopkins Hospital. In 1919 he was appointed chief of the medical departments of the new League of Red Cross Societies in Geneva, a position he held for two years.

In 1937 Mrs. Alfred I. du Pont invited a group of doctors, including Dr. Brown, to act as an advisory board in planning a hospital provided for in the will of her husband. He was elected chairman of the medical board and had never missed a meeting until last year when poor health greatly restricted his activities.

Byron T. Banghart, B.A. '05, September 23.

J. William Beckmann, fac. '26–'28, September 8.

Ruth Foster, '20–'21, '23–'26, fac. '32–'35, September 29.

Thomas Baxter Gresham, '26–'28, August 28, 1949.

Charles H. Halliday, '29–'30, September 30.

George Henry Heitmuller, B.A. '91, May 23.

Robert Thomas Kerlin, g. '89–'90, February 21.

Frank Abbott Magruder, Ph.D. '11, December 2, 1949.

W. Fletcher McPhedran, fac. '10–11, May 16.

James B. Murphy, M.D. '09, August 24.

Charles Augustus Myers, B.A. '02, Ph.D. '09, fac. '09–'16, June 8.

Joseph C. Nyce, Jr., '94–'97, December 31, 1949.

David Chin Park, g. '42–'43, November 4, 1948.

Francis Le Jau Parker, Ph.D. '01, August 20, 1945.

Edgar Poe Sandrock, B.A. '03, M.D. '07, fac. '23–'25, August 24.

L. Howard Smith, M.D. '15, December 22, 1949.

John C. Southard, Ph.D. '30, September 4.

Lewis Thorne, fac. '37–'39, October 8.

Jesse L. Webb, '15–'17, October 6.

David E. Weglein, B.A. '97, Ph.D. '16, fac. '17–'46, October 10.

Worrallo Whitney, g. '88–'89, March 10, 1948.

Julius Terrass Willard, g. '87–'88, July 26.

Bertram S. Winchester, B.S. '17, September 29.

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ISOTOPES IN MEDICINE

Continued from Page 14

pletely practicable—with isotopic techniques.

SOME three and a half years ago—in May, 1947—two members of the Johns Hopkins medical faculty, Dr. Frederick W. Barnes, Jr. and Dr. Samuel A. Talbot, submitted a proposal to the University.

Like a number of their colleagues, Doctors Barnes and Talbot had been exploring the use of isotopes in their medical research. Like their colleagues, they had become convinced that in the use of isotopes lay one of the most promising, one of the most revolutionary and far-reaching, possibilities for forwarding medical knowledge which had ever occurred in medicine. They were satisfied that here, if only it could be taken advantage of fully, was a potential development which could bring to medical science—and to human welfare—the opportunity to make advances of the utmost benefit.

But they had discovered, also, that there were problems, facing anyone attempting such work, which were immense. There were problems of getting extremely accurate measurements of results; incredible exactness was required, for which instruments and machines and techniques of great complexity must be brought into play. There were problems of electronics, of chemistry, of biochemistry, of biology, of engineering—with which only specialists who had long trained in such fields were prepared to cope. Such, at least, was the situation if medical research was to use isotopes to the fullest degree—if medical science was to make the most of the tremendous potential which the use of isotopes seemed to offer.

The proposal which Doctors Barnes and Talbot submitted to the University suggested that Johns Hopkins set up a central organization in its medical institutions which could employ the specialists and assemble the instruments necessary to implement the use of isotopes in medicine. The proposal was long and detailed, and it contained some estimates of what the project would cost. The figures after the dollar signs were not small: some of the instruments required were selling commercially for around $10,000 apiece, and even these would not be adaptable to changes which, as greater and greater sensitivity became necessary, the medical scientists would require. But if isotopes were to be used—and used most effectively—expenditures would have to be made; besides, if the promise of isotopes was as true as it seemed to be, the opportunity it offered to medical research simply could not be passed by.

The University considered the proposal. It implied a great emphasis at Hopkins on the use of stable isotopes—the harder kind to work with, as we have seen, because they emit no convenient radiations and activate no Geiger counters, but exist in a state which only the tough-to-use mass spectrometer can detect and measure. There were three compelling facts which were clear to the University:

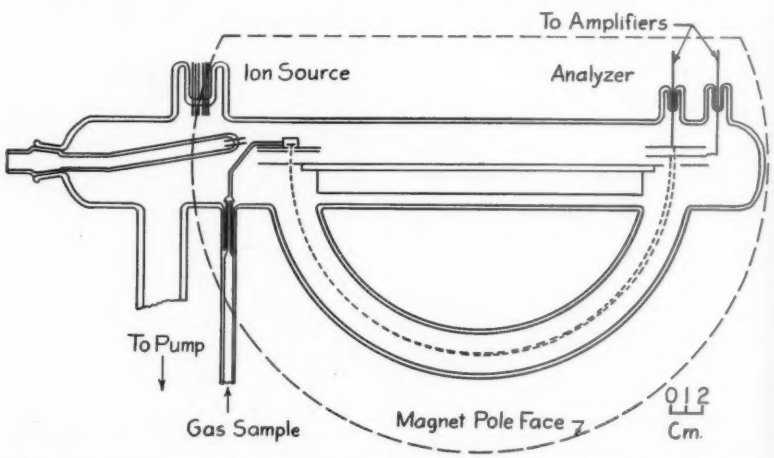
First, the great tracer importance of stable isotopes, particularly in biological research. Second, the large amount of knowledge in those highly technical fields such as biochemistry, physics, and the others mentioned above, which is needed in the proper use of isotopes. Third, the tremendous difficulty of adequate instrumentation: only a few laboratories would be able to produce the results needed in the biological aspects of stable-isotope techniques, because of the pressing need for instrument dependability.

One of these three factors alone, probably, would not have been sufficient justification for the establishment of an isotope research center. Put together, however, they made the center's establishment a virtual necessity, without which the important emphasis on stable-isotope work at Johns Hopkins would not be possible.

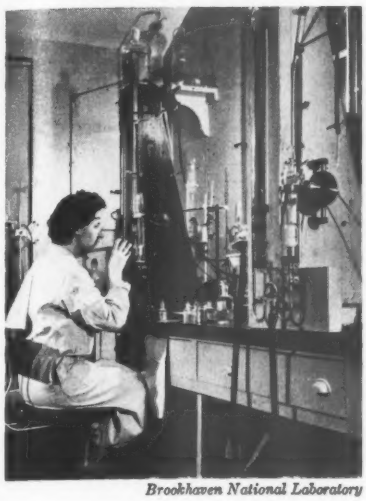
With Dr. Theodore Enns engaged to direct it, and with the Thomas Courtney Jenkins Biophysics Fund financing it at first, the Isotope Research Center came into being at the Johns Hopkins Medical Institutions.

THE Isotope Research Center, under Dr. Enns, affords to Johns Hopkins medical investigators an opportunity for constructive consultation on the use of isotopes in their work. It is in no sense an agency designed to police or to influence research itself; but, because Dr. Enns and his staff are specialists in a highly complex field, the Center can help individual medical research people to formulate their problems, aid them in avoiding pitfalls in their uses of isotopes, recommend equipment, supply references, and help them (in an entirely advisory capacity) to interpret their results.

And, most impressive of all, the



THIS DIAGRAM illustrates the 180-degree mass spectrometer at Johns Hopkins School of Medicine's Isotope Research Center, pictured in photograph on Page 14. The D-shaped tube arrangement shown here is discernible in that photograph. At upper left, a beam of isotopes enters the "D" (broken line). It moves (left, bottom) into the field of a magnet, where lighter isotopes are pulled closer to the magnet than heavier ones—i.e., isotopes in the original beam are sorted out by their weights into separate beams. All isotopes in each beam, at that point, have an identical mass; thus the presence of different isotopes in the original beam has been identified. This enables medical researchers to incorporate a tracer isotope (it makes no difference to the mass spectrometer whether it is radioactive or stable) into a substance, feed it to an animal, and then, by analyzing the animal's tissues in this instrument, determine how the animal's body has used the substance. Construction of a mass spectrometer like this requires precision work of a high-quality, optical-instrument calibre; its vacuum system must be unusually good, and a tolerance of less than a thousandth of an inch is permitted in its individual parts. For these reasons, truly fine instruments are rather rare.



Brookhaven National Laboratory

BODY FLUIDS and tissues are analyzed for carbon content by this instrument, a Van Slyke gas machine. With the machine, it is possible to measure total carbon in a tissue and later estimate the fraction which is radioactive—and to carry out these analyses serially on a single sample of minute size.

Center has been able to provide measurement equipment of the highest order —much of it built by Dr. Enns himself to meet the unbelievably strict specifications of the work, and not commercially available. The importance of such equipment cannot be overemphasized; without instruments which are precise, the results of medical research with isotopes are badly limited and, as research progresses, practically unattainable.

At the heart of the Isotope Research Center are Dr. Enns' mass spectrometers. In principle, they are rather simple; but constructing them is something else again.

The mass spectrometer is essentially a magnetic prism. It separates a beam of isotopes (electrically charged for this purpose) into *separate* beams, according to the mass of isotopes making up the original beam. The separate beams are then measured as very small electric currents, and their relative abundances calculated from these measurements. The process is quite comparable to the action of a light prism, which receives a beam of light and separates it into the colors of the spectrum.

For medical-tracer purposes, the percentage of atoms of a rare isotope in a given substance is increased. The resultant material is then applied to the experiment. Test material from the experiment is then processed chemically and admitted to the mass spectrometer. The instrument measures the amount of

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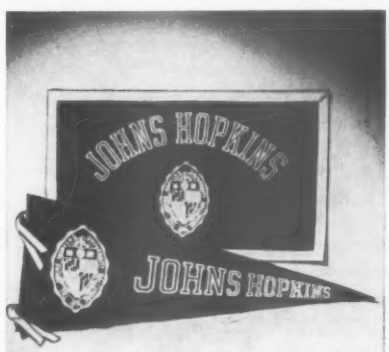

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unnatural enrichment of the rare isotope and thus tells the operator how much of the isotope enrichment has reached the test material.

Let us again use the example of light and heavy hydrogen. Let us imagine that a beam of hydrogen isotopes is introduced into the mass spectrometer; the beam is a mixture of hydrogen 1 and hydrogen 2. The mass spectrometer's magnet will break this single beam into *two* beams: it will attract the lighter isotopes of hydrogen closer to it than the heavier isotopes of hydrogen, thus producing two beams each composed of isotopes of identical mass. The presence of the hydrogen isotopes in test material is thus detected; and the relative abundances of the light and heavy isotopes can be measured.

Basically, this seems simple enough. But construction of a mass spectrometer which will perform these functions satisfactorily involves many specialized techniques of physics, chief among them being optics, high-vacuum construction, and detection of the smallest measurable electric currents. Since the mass spectrometer operates like an optical spectrometer, its slit systems and lenses require the same precise construction.

All this must then be housed in an evacuated tube at one-billionth atmospheric pressure. Finally, the isotope currents detected range down to one thousand electrons per second, or one ten-thousandth of one millionth of one millionth of an ampere. Add to these the normal physical problems of supplying extremely stable electrical power to several components of the instrument, and one has a total technical problem of considerable magnitude.

That such instruments, and such a center, are available to Hopkins medical researchers, along with the know-how to operate them with precision, strengthens greatly the opportunities for progress in medical research at the University. And as the projects of research become more and more complex, the Center is there, with its highly qualified staff, to keep pace by supplying them with the instruments and the advice which may be called for.

THE use of isotopes in medicine has, relatively speaking, only begun. But it is fast-growing. New tools, new knowlege, new procedures will continue to make possible still higher standards—and thus ever higher goals—in research. The eventual benefits, added to those already gained, should be extensive indeed. The possibilities, even the most cautious of medical scientists will admit, constitute one of the most exciting facts in medicine today.

NEARLY EVERYONE IS USING THE ATOM

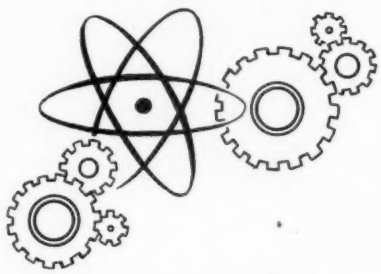
Continued from Page 17

even more ingenious uses for the isotopes. Sportsmen are getting interested: we now even hear of radioactive golf balls, with Geiger counters replacing caddies for locating balls in the rough! And it has been suggested that critical war metals be tagged with isotopes to thwart black marketeers.

Although these processes are not difficult in themselves, they do have certain specialized problems. One of the largest is the disposal of radioactive waste, from the atomic piles which "manufacture" radioactive materials and from the many projects which use them. Sanitary engineers at Hopkins are investigating the dangers of disposal by existent sewage disposal methods and, in conjunction with members of the School of Hygiene, the possibilities of destroying the waste by incineration.

ATOMIC energy seemed at first to be a wonder fuel which would solve all power problems. Longer study has revealed two important drawbacks: it is relatively expensive, and it requires insulation so heavy as to make it impractical for certain jobs. These disadvantages are far from prohibitive, however.

Power plants are already well along in the planning process. Reliable estimates foresee practical plants in ten years, with a steady reduction in cost making them generally available within twenty-five years. Cities will be able to offer heat as a utility; smog can be



eliminated and, as a consequence, urban health improved. Of greatest importance, no nation need be power-hungry.

Such plants will always be expensive, and it is unlikely that areas where coal is abundant and water power cheap will ever find them practical. But countries which are short on these natural resources may well find atomic power less expensive than their present power source.

The bulk and weight of the insulation for an atomic engine make it impractical for most forms of transportation. Where weight is not a negative factor, however, we may soon see the use of atomic power. The Navy is already at work on atomic-powered submarines, a craft peculiarly suited because it already carries excess lead in order to weight it down. Such engines may also appear on large surface ships and perhaps trains when weight and cost are deemed less important than high performance.

Radioactive materials are not nearly as scarce as we first believed. We now know to be available enough to supply a century of power for the world. Undoubtedly this amount will be increased. First, through new finds; prospecting has barely started and there is no way to estimate how much uranium will be found.

Second, experiments are under way to "breed" more radioactive material. On Naval Proving Ground property at Arco, Idaho, scientists are working on a method of converting abundant nonfissionable uranium 238 into fissionable plutonium. If the project is successful (and the outcome should be known in 1951), it can produce fissionable material up to one hundred and forty times the amount of uranium 235 which appears naturally.

WHERE the Age of Radiation will take us none of us knows. But it is worthwhile recalling David Lilienthal's estimate that the next decade may bring as great advances in health, agriculture, and production as did a century in the past.

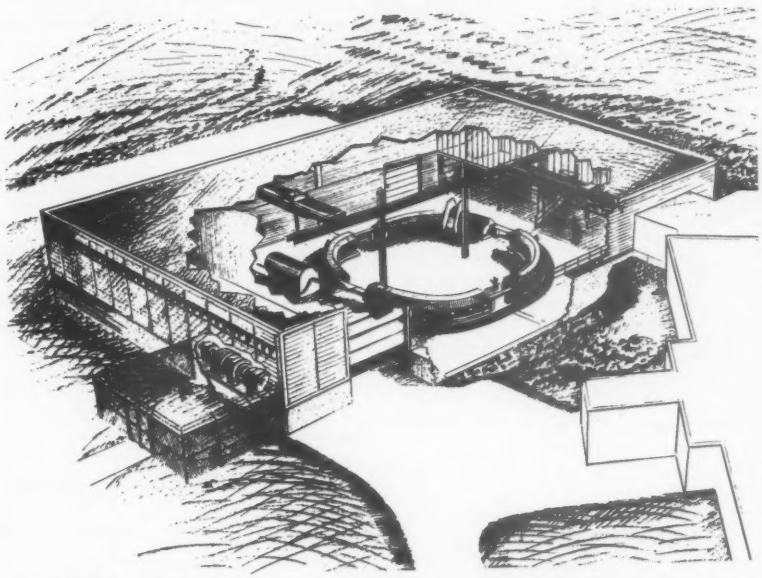
BROOKHAVEN NATIONAL LABORATORY

Continued from Page 8

part not known to the degree of accuracy one would desire. One of these properties is the mass, which is a measure of the total energy content. The most accurate measurements of nuclear masses have been made by determining the deviation in path of an ion moving in a magnetic field. The great advances made in World War II with electronic-timing methods suggest that a method based on measuring the time of flight of a pulse of ions moving in a magnetic field might permit greater accuracy to be achieved. A preliminary experimental test of this approach has been made at the Laboratory in an instrument known as the "chronotron"; it does indeed show considerable promise. The spins and magnetic moments of nuclei in their ground states are also being measured at the Laboratory by techniques made possible by radar developments.

Research in theoretical physics at the Laboratory is directed toward a better understanding of nuclear forces. Contributions have been made to the general quantum mechanical theory of interacting fields (such as electric or magnetic fields). This subject contains contradictory difficulties which are one of the principal concerns of present-day theoretical physics. Problems which arise in the experimental program are also analyzed.

BROOKHAVEN maintains its own weather station. Above, the head of the meteorology group analyzes weather charts.



ARTIST'S CONCEPTION OF BROOKHAVEN'S COSMOTRON (SEE PAGE 6)

THE techniques of chemistry are useful in studying nuclear problems. The physicist determines the probability of a nuclear reaction by measuring the attenuation of a beam of radiation, or by counting the particles formed in the reaction. The chemist attacks the problem in a somewhat more leisurely but no less painstaking fashion by isolating the radioactive reaction products and measuring their amount. The probabilities of rare modes of fission are thus being studied, and it is planned to measure quantitatively the yields of disintegrations caused by the reactor, cyclotron, and Van de Graaff.

In order to make these measurements, it is necessary to know the radiations emitted from the active material, their energies, and the way in which the decay may branch between alternate routes. This aggregate of information is known as the "decay scheme" of the nucleus. From the earlier discussion it will be seen that the information has theoretical as well as practical significance. Several decay schemes have been studied, with emphasis on isomer transitions and electron capture. The latter is a process in which the nucleus swallows one of the atomic electrons.

In this work a new type of radiation counter, an X-ray proportional counter, has been used to great advantage. It permits one to make quantitative measurements of the spectrum of the characteristic X-rays which follow isomeric transition or electron capture.

The instrument has also been used in experiments which showed that the emission of a beta particle or an alpha particle from a radioactive nucleus causes the ejection of an electron from an inner orbit of the emitting atom, with a probability of about one in ten thousand.

TURNING to applications of isotopes in chemistry, much use has been made by chemists since 1920 of the fact that isotopes of a given element are physically distinguishable but have almost identical chemical properties. One such application is to reveal and measure the rate of exchange reactions. These

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Beverage glasses and cocktail shaker, for instance. Glasses and shaker have the Hopkins seal, gold and sable, on them. Ideal, we think, for giving a round of refreshments a handsome "good taste." Shaker is just $3.75, postpaid. Glasses (please specify whether you want highball glasses, cocktail glasses, or old fashioned glasses), are only $3.50 a dozen, postpaid. (Sold in dozen lots only.)

Another out-of-the-ordinary item in the collection is the Hopkins-seal wastebasket. It is black trimmed in gold, with the seal in full colors: $3.75, postpaid. Matching cocktail tray, 12 by 18 inches, is just $3.75, postpaid.

To round out the group, we've a low-priced—yet expensive-looking—collection of Hopkins-emblem ashtrays. Jumbo-size ashtrays, six inches across, are just 50 cents, postpaid. For bridge, we have coaster sizes: 70 cents for four, postpaid. Hopkins-seal matches (with the seal in full color), 50 books to the carton, are 35 cents a carton. And for club cellar or the wall of your study, the full-color Hopkins seal, suitable for framing, comes in a handsome reproduction at just 50 cents.

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are reactions in which two atoms are exchanged between two different states of chemical combination.

Suppose, for example, that we have a water solution of iron salts, with part of the iron in its trivalent state, Fe^{+++}, part in its divalent state, Fe^{++}, which has one more electron. When two such ions collide, do they maintain their identity?

If an electron is transferred from the divalent to the trivalent ion, the one which was originally doubly charged will now be triply charged, and that which was triply charged will now be doubly charged. The occurrence of this process has been demonstrated and its rate measured by determining the rate at which radioactive iron originally present only as Fe^{+++} appears in the Fe^{++} species.

The chemical differences between the isotopes of an element are so small as to be negligible in most work. Nevertheless they exist, and they assume considerable magnitude for the lightest elements. It is just these differences which are the basis of the separation of isotopes by chemical exchange reactions, such as those used on a large scale at present for the production of separated isotopes of carbon and nitrogen.

Knowledge of the effects of isotopes on chemical properties has been advanced theoretically and experimentally at Brookhaven. The different rates of reactions involving carbon isotopes have been given special attention, because of the wide use of C^{13} and C^{14} tracers in chemistry and the life sciences. Ordinary carbon contains about ninety-nine per cent C^{12}, one per cent C^{13}. Alterations in the C^{13}/C^{12} ratio during the course of a reaction are measured with a high-precision mass spectrometer. The effects observed are well accounted for by the theory which has been concurrently developed.

IN the generation of atomic energy, both in bombs and in more peaceable devices, very intense high-energy radiations are produced. The changes caused by these in chemical compounds and in living systems are of great importance. These effects are investigated at Brookhaven in medicine, biology, and chemistry.

In chemistry, high-energy electrons and X-rays are being used to study the radiation chemistry of water and water solutions. These systems are selected because water is a very important substance—it is well-nigh the universal solvent and is, of course, the main constituent of most living organisms.

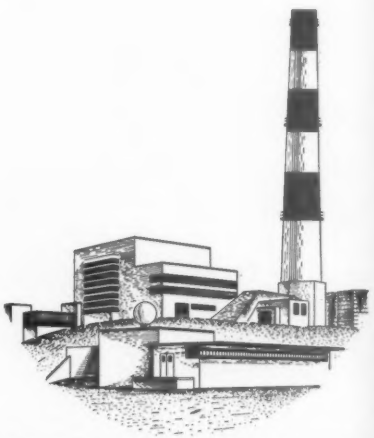
It is believed that the observed chemical changes come about mostly as a result of the following steps: the radiation knocks a water molecule, H_2O, apart into two very reactive free radicals, H and OH. These participate in reactions which form H_2, O_2, H_2O_2, and other products, depending on what substances are present besides water.

The aim of the experiments is to measure the number of primary radicals formed by a given radiation dose, and to characterize the ensuing reactions and measure their rates.

Since the generation of atomic energy involves the heavy elements uranium and its neighbors, and since these are inevitably subject to chemical processing, increased knowledge of their chemistry is very desirable. The electronic arrangements, which determine the chemical properties, are being studied through magnetic and spectroscopic measurements on compounds of these elements.

RESEARCH in the life sciences, biology and medicine, is concerned with the effects of radiation on living systems and with the use of isotopes in unraveling the very complex chemical reactions which occur in them.

Growing plants are continuously exposed to gamma radiation in a three-acre field at Brookhaven. The radiation comes from a sample of radioactive cobalt 60, equivalent to about twenty grams of radium, supported in the center of the field. Plants are grown in concentric circles around the source. The



REACTOR at Brookhaven and its supporting elements are housed in this complex of buildings. Striped tower, one of tallest structures on Long Island, exhausts wastes safely.

closest plants are bathed in radiation at an intensity about five thousand times that which is considered tolerable for human exposure; those farthest from the center, in about a tenth of a per cent of this amount.

The effects on the growth of the plants are observed; the production of mutations is studied in controlled genetic experiments; the changes inside the individual cells themselves are measured by delicate techniques. Some plants are found to grow little or not at all at intermediate dosage rates; others grow apparently normally even close to the radiation source. Even these, however, experience changes in their germ cells which cause mutations to show up in successive generations. New strains of corn, for example, are produced. One of them is very similar to a primitive grass from which corn may have originally evolved.

There is some evidence that occasionally a radiation mutation may lead to a plant strain of improved properties. Close watch is kept to detect and cultivate such strains.

Mutations of the bacteria *E. coli* caused by exposure to radioactive phosphorus, P^{32}, are being studied. Here a most interesting fact has been discovered. Cells containing the active phosphorus mutate at a much greater rate than ones exposed to the same radiation dose from an external source. The conclusion seems inescapable that the effect is in some way associated with the sulfur atom, stable S^{32}, into which the phosphorus is transformed, rather than to the penetrating beta particle which it emits.

A striking effect of X-ray exposure on rats is the increased water turnover. The rats drink and excrete much more water than normal, and will fight each other for access to a limited water supply. It has been found that if serum from an irradiated rat is injected into an unexposed rat, the latter excretes water faster than do controls which receive serum from unirradiated animals. The water-turnover effect is thus apparently due to an alteration in the com-

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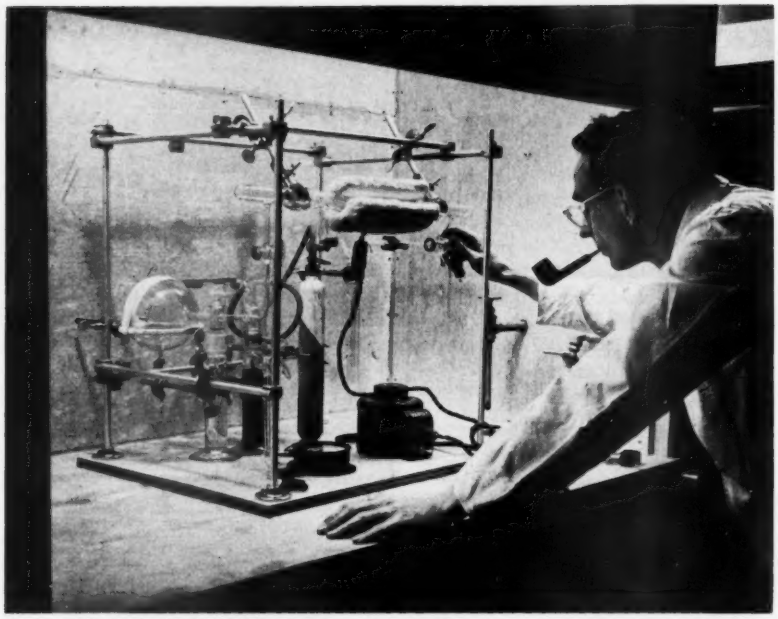

NEW SYNTHETIC METHOD for introducing radioactive carbon into complex organic molecules is investigated by Brookhaven National Laboratory chemist. If, by this method, radioactive carbon can be combined with certain compounds, the resultant mixtures can be used as tracers in biological studies.

position of the serum; it is believed that the radiation interferes with normal hormone secretions of the pituitary gland.

The adrenal gland also plays an important part in an animal's response to radiation. Removal of the adrenal gland makes a rat more susceptible to whole body X-radiation; treatment with adrenal-gland extracts restores his ability to withstand this stress. Indeed it has been found that protecting the adrenal glands with internal lead shields greatly increases the normal animal's resistance to radiation.

RADIOACTIVE tracers are being used to study the turnover of phosphorus, iron, and carbon in the body. The amounts of the thousands of compounds which are the body's constituents are essentially constant. Conversions between them are therefore not detectable by chemical analysis, but they can be revealed by the migration of tracer isotopes from one chemical species to another.

Being studied in this way are: the rate of formation in the liver of phosphorus compounds involved in the metabolism of fats and sugars; the disturbances in the formation of these caused by diabetes; the turnover of phosphorus compounds in the brain; and the incorporation of iron in the blood. With radioactive carbon it has been found that sugar carbon atoms are selectively burned and excreted as carbon dioxide much more rapidly than was formerly presumed to be the case. With some truth it might be said that sugar is fattening more because it is burned in place of body carbon atoms that would otherwise be burned, rather than because its atoms become converted to body carbon.

Both biologists and chemists are concerned with the synthesis of C^{14}-labelled compounds for such tracer applications. In a recent joint enterprise, carbon dioxide containing radioactive C^{14} was fed to photosynthesizing bean leaves, from which the sugar glucose was later isolated; this was converted by a succession of chemical and biosynthetic steps to C^{14}-labelled ascorbic acid, or vitamin C. The radioactive vitamin will be used to study the role of this essential compound in plant and animal metabolism.

SAFETY DEVICES protect workers with radioactive materials. The man above is checking himself for contamination on a hand-and-foot counter, one of the thousands of variations on Geiger counters which are sensitive enough to detect and indicate the radioactivity of even a single atom.

Research patients are referred to the Medical Department by hospitals in the surrounding area. They have comprised persons with thyroid cancer, leukemia, Graves' disease (a type of goiter), and nephrosis (a children's disease in which the balance of body fluids is upset). Patients with thyroid cancer are treated with radioactive iodine, I^{131}, which concentrates in the tumor and tends selectively to destroy it. The limitations of this therapy are being evaluated. Radioactive sodium is being used in cases of nephrosis to study the distribution of body sodium and its rate of turnover in the fluid responsible for distension of the limbs and abdomen in the affected children. It has been found that volume of extracellular fluid is sometimes more than twice the normal figure.

It is believed that the results of these studies will aid in understanding the disease and will have immediate application with respect to drug dosage and manner of administration to nephrotic children stricken with the all-too-often fatal secondary infections to which they are subject.

THE writer has scarcely hoped to give an adequate, much less complete, survey of the studies in which a staff of two hundred scientists are engaged at the Brookhaven National Laboratory. Perhaps enough has been said to indicate the direction of some of the major lines of effort, and their aims.

Some of these aims have immediate reference to human well-being, especially in the life sciences. Yet in these as well as in the physical sciences, the ultimate goals—in the sense of tangible benefits to mankind—are unstatable, because unknown. One knows that additions to man's knowledge can be put to man's benefit in unsuspected ways; ignorance never can. Brookhaven represents an important attempt to extend man's knowledge in the vast and far-reaching field of atomic energy.

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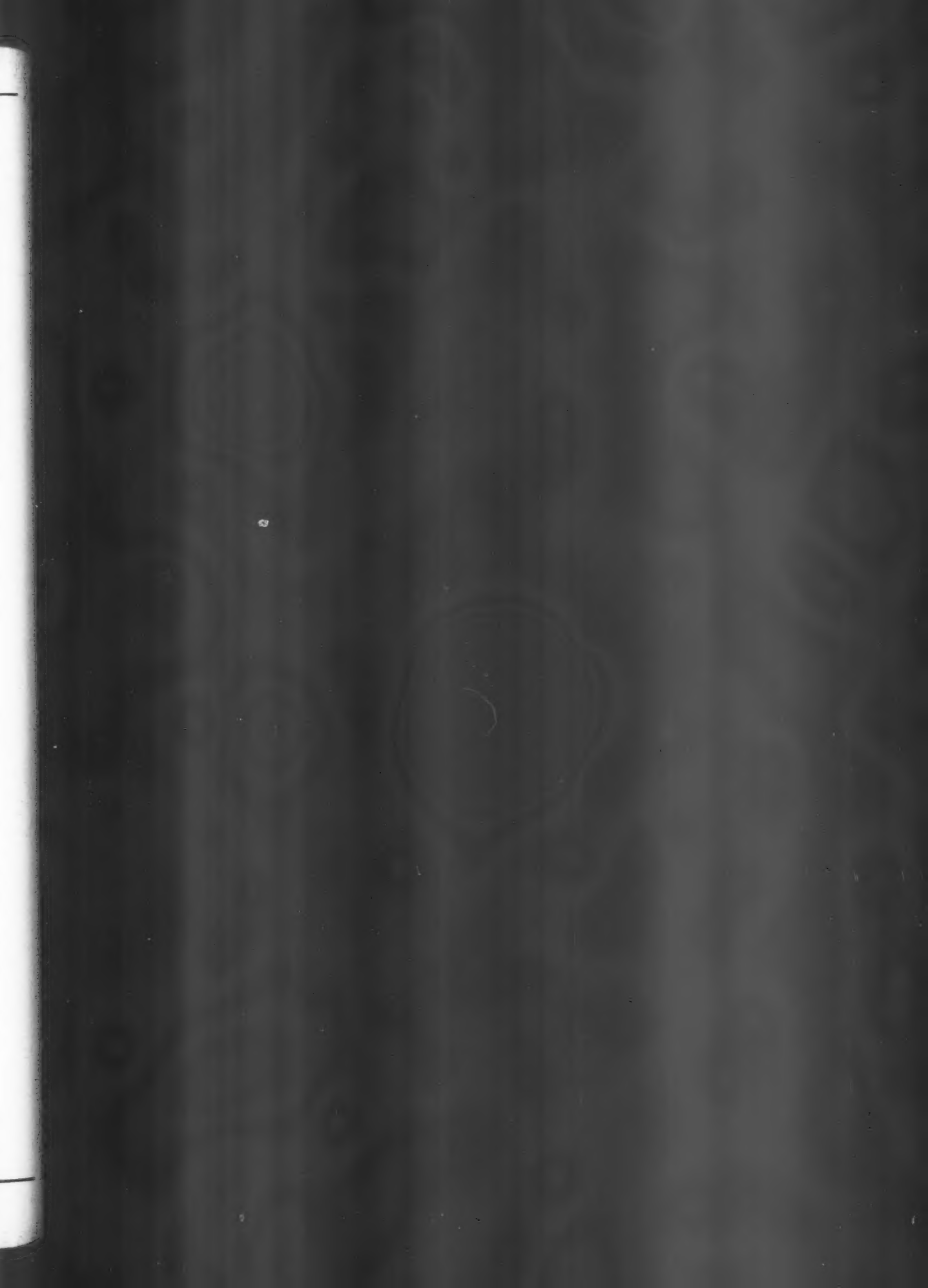
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